INSECTS

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PREFACE

THIS BOOK attempts to present a glimpse of some of the wonders of insect life of India. Insect life in our country is extremely rich and greatly diversified and is perhaps unsurpassed for its beauty and specializations anywhere else in the world. In writing this book, we have, therefore, constantly been faced with one great difficulty: not what to say, but what not to say. We have deliberately chosen to leave out much that a specialist will miss; indeed this book is not written for the entomologist. We have included only what is likely to interest the general reader. We have also striven, as far as possible, to avoid the use of technical jargon and to describe in a simple manner some of the more outstanding facts of insect life in India which we have personally observed in the course of nearly four decades of our wanderings.

Our approach is also to a large extent unorthodox. The central idea throughout the book is that insect life in India is inseparably bound with that of man for mutual benefit. We believe that inter-dependence, mutual adjustments and tolerance have been formed between insects and man in India during the past seven thousand years at least, and a happy balance in Nature has come to exist. We have striven to show that in ancient times, our forefathers greatly valued this partnership, one which man is now abusing in his hurry to break away from ancient traditions. We have stressed the fundamental similarities between insect and human lives in India emphasizing that our insects are truly Indians and share our national traits, our greatness and our shortcomings. These ideas would no doubt sound heretical to entomologists, to whom every insect is a "pest" that must be "controlled". Our aim has been to stimulate interest in and love for insect life in our country.

The photographs, which we have reproduced here, are selected from a large collection that we have accumulated over the years and show mostly living insects in their characteristic attitudes.

We would feel adequately rewarded if this book creates an abiding interest in insect life in India.

M. S. MANI

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CHAPTER I

THE INSECT LEGION

What Are Insects?

From time immemorial our Rishis and poets have admired the wealth and beauty of the vegetation that lends enchantment to the Indian landscape. It is not, however, widely realised that this vegetation owes its existence to the labours of insects. Strange as it may sound, there would be no flowers, no seeds and fruits and no forests if insects were absent from the scene. We could neither raise a single crop or fruit nor make our clothing. We generally seem to be convinced that the lovely flowers of our land bloom so that we may enjoy their beauty and scent and worship our gods and garland our heroes. The truth is, however, that the plants bring forth flowers for the enjoyment not of man but of insects, for the express purpose of attracting the insects and for enabling them to effect cross-pollination. Man's interest in flowers is purely incidental. It is not also generally realized that in the absence of insects, the land would be hopelessly contaminated and full of filth and decaying matter. Many of our prized food-fishes and garden birds would not also survive. There would of course be no honey or silk. Truly insects may be described as the architects of our landscape, and the patrons of our agriculture, industry and civilization.

We are all only too familiar with insects—mosquitoes, flies, bedbugs, ants, butterflies, bees and many others. They are readily recognizable by their six legs. Indeed it is for this reason that they were named *shadpada* (six-legged) in Sanskrit, long before the scientists in Europe coined the Latin name Hexapoda (six-legged).

The insect differs from the spider, the scorpion, the millipede and the centipede in that it has a distinct head, a separate trunk or thorax and a separate belly or abdomen. On its head it bears a pair of highly sensitive feelers (antennae), with which it not only feels its way about but also smells, receives and transmits wireless

messages and does many other inconceivably wonderful things. The head bears also a pair of most complex organs of vision, the compound eye, which is often made up of over 20,000 separate eyes. The six legs are confined to the thorax. In most insects the thorax bears one or two pairs of wings. The insects were indeed the first animals on the earth which really flew, millions of years before even the birds.

A marvel of the anatomy of the insect is that its body is enclosed in a case of hollow armour plates that combines in itself the advantages of lightness, compactness, rigidity, flexibility, mechanical strength and resistance to numerous corrosive and harmful chemicals. The armour plates constitute its skeleton which lies superficially on the body and at the same time is not heavy and bony like ours. The remarkable properties of this exoskeleton (external skeleton) may be traced to the complex chemical compound called chitin. Another marvel of insect anatomy is its respiration. In man and most other animals with which we are familiar, the air is breathed into the lungs where the heart pumps the blood for the exchange of the oxygen of the air for its carbon dioxide. The blood then carries the essential supply of oxygen to the tissues. This is made possible by the presence in the blood of a special respiratory pigment known as haemoglobin which has a high affinity for oxygen and forms with it an unstable compound capable of readily parting with the oxygen to the tissues. There is, however, no haemoglobin in insect blood, which has no respiratory function and there are no lungs. The air is carried directly to the interior of the very cell that needs it by a system of delicate branching tubes called tracheae. This fact accounts for the astonishing powers of endurance and muscular strength of insects. A staghorn beetle can, for example, drag a load that is ninety times heavier than itself over a distance thirty times its own length for almost half an hour without getting tired. The common flea, with legs hardly a millimetre long, can jump a horizontal distance of about 32 cm and a height of 20 cm. If man (180 cm tall) were to compete with the flea in a jumping competition, he would have to do a long jump of a quarter of a kilometre and a high jump of

137 m. The size of insects ranges between very wide limits; there are tiny ones hardly visible to the naked eye and mighty giants. The smallest insect is smaller than a large amoeba and measures less than 0.25 mm long and the largest insect, a fossil dragonfly, was 75 cm long. The insect giant is thus three hundred times bigger than the insect dwarf.

The colours of insects are as varied as their sizes. Some are of dull and sombre colours, while others are most gorgeously white, yellow, orange, red, brown, green, blue, violet or black. Many are iridescent and coloured metallic green, blue or coppery-red. Most have bright spots, bands or marks, with beautiful patterns of contrasting colours. Some beetles, butterflies and moths are of great beauty. The wide range of colours is due either to specific pigments or to multiple reflections, selective absorption, refraction, defraction and scattering or interference of light waves by the peculiarities in the minute structure of the body integument. The common pigments of insects are derived from the food of the young and are generally derivatives of the chlorophyll of the leaves, carotinoid pigments, melanin, etc. The white colour of many insects is often due to deposits of urate crystals. The peculiarities of the microstructure of the integument give rise to iridescent green, blue, red or violet. The colours of butterflies and moths and many of our iridescent beetles are not due to the presence of a colouring matter or pigment but are the result of light waves.

An Ancient Group

The insects are an ancient group of animals. They are known as fossils from the Carboniferous Epoch of the great Palaeozoic Era (300,000,000 years ago). The oldest known insects belonged to an extinct order called Palaeodyctioptera. They were fully winged creatures which flew rather clumsily. They had, in addition to the two pairs of wings like most modern insects, a pair of short, semi-circular or oval wing-like lobes in front of the wings. The adult Palaeodyctiopteran was a short-lived aerial creature which enjoyed not more than a few hours of sunshine and air. The immature stages were long-lived, aquatic animals which underwent

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a slow and prolonged development, extending often over a year or two years or more. Besides the Palaeodyctiopterans, there were also gigantic cockroaches during the Carboniferous Epoch. Compared to the insects, man, who came on the scene of life on the earth hardly a quarter of a million years ago, is a very young upstart. Long before this event, the insects had completely colonized the whole surface of the Earth, and had complete domination over the living world. Even now the insects are the real owners of our planet, and man is a trespasser on their private property.

Where Do They Occur ?

Insects are found everywhere on the earth, from the sea-shore to the bleak slopes of the highest mountains, in arid steppes and deserts, in dense and humid forests, grasslands, kitchen-gardens, orchards, fields, in lakes, ponds, marshes, rivers, streams, springs and wells, in caves, in the soil, in snowfields and glaciers on high mountains, in the cold arctic and antarctic regions, inside the human dwelling, kitchen, office, school, college, laboratory, store, factory, library, museum, on or inside plants, and the bodies of man and various other animals. You will find them under a stone that you may turn over, beneath a fallen leaf, on and under the bark of trees, in decaying vegetable and animal matter, in manure pits, granaries, manufactured goods, book shelves, clothing. There is not a single square centimetre on the Earth's surface where one or another kind of insect is not found.

How Numerous Are Insects ?

As individuals and as species, the insects far outnumber all other groups of animals combined. Over three-quarters of a million species of insects have already been named and described by scientists. Competent authorities have estimated that this represents only a small fraction of the total number of species still awaiting discovery by man. Descriptions of insects occupy whole libraries; and more naturalists are devoted to the study of insects than of other groups of animals and plants.

The rate of multiplication of insect population is inconceivably

high. Even though their mortality rate is enormous by human standards, they have successfully maintained their dominance through geological ages and have extended it to newer areas. Vast as the number of species at the present time may appear, it is really small, because countless millions of species have become extinct during the geological past. Though over 12,000 fossil species of insects have already been named and described, they form only a fraction of the millions of species which had lived and disappeared without being preserved as fossils. Naturally, the classification of such a vast group presents difficulties.

How Are Insects Classified?

Insects belong to the animal group called Phylum Arthropoda (animals with jointed legs), which also includes such familiar animals as the crayfish, lobster, prawn, crab (ten legs); scorpion, spider, mite and tick (eight legs); millipede and centipede (about two dozen legs).

Scientists have classified insects into thirty-four Orders, which are divided and subdivided into numerous families, subfamilies, genera and species, mainly on the basis of characteristic differences in the structure of their wings, their mode of feeding, the development of their young and the associated modifications in their anatomy.

How Are Insects Named?

The scientific name of an insect, like that of any other animal or of a plant, is internationally accepted and consists of two parts. This method is known as the binomial (two names) system of nomenclature. It came into being in 1758, the date of publication of the tenth edition of the monumental book *Systema-Naturae* by Carl von Linne (also known as Linnaeus), a Swedish naturalist. The first part of the scientific name, written with an initial capital letter, denotes the genus and the second name, written with an initial small letter, the species. The common housefly is, for example, named *Musca nebulo*. The common cockroach is known as *Periplaneta americana*. The ubiquitous bedbug is called *Cimex*

rotundatus and the desert locust *Schistocerca gregaria.* These names are given by specialists, strictly in accordance with the Rules of International Zoological Nomenclature, which are followed in all countries, irrespective of political or other differences.

Parade of Insect Orders

The following is a brief account of the major Orders of living insects according to the modern classification:

Order 1. EPHEMERIDA—Mayflies. The immature stages are aquatic, undergoing prolonged development, extending often to over a year; the adult has two pairs of wings, and lives hardly for a few hours. It does not feed in the sexually mature adult life, but swallows a quantity of air to increase the buoyancy of the body which facilitates the nuptial flight. The female lays eggs in water and dies soon afterwards.

Order 2. PLECOPTERA—Stoneflies. The immature stages breed in cold, clean mountain streams for one or two years. The sexually mature and two-winged adult stonefly emerges during the coldest part of the year, crawls under stones and mates. After the eggs have been laid, the adult dies.

Order 3. ODONATA—Dragonflies and damselflies. They are voracious hunters, both in the immature and adult stages. The immature stages live in water. The adult has two pairs of wings, powerful fliers, and very large compound eyes occupying nearly the whole surface of the head. Its legs are spined and form a sort of loose-mesh basket for carrying prey captured while flying.

Order 4. ORTHOPTERA—Grasshoppers, locusts and crickets. They are terrestrial insects, with two pairs of wings, of which the front pair is modified into a leathery narrow tegmina and the hind wings are membranous and large. The hind legs are longer and stouter than the others and are suitable for jumping. These insects feed mostly on plants.

Order 5. PHASMIDA—Leaf-insect and stick-insect. Their body is curiously flattened like a leaf or narrow and slender like a stick.

Order 6. DERMAPTERA—Earwigs. They are generally dark-coloured and hard-bodied with short and horny fore wings which

conceal the membranous hind wings and do not cover the whole of the abdomen. The tip of their body bears a pair of long pincer-like appendages (forceps). They usually live underground and feed on roots of plants.

Order 7. BLATTARIA—Cockroaches. They are fast-running insects with flat bodies. Their fore wings are leathery and hind wings membranous. They are omnivorous in habits.

Order 8. MANTODEA—Praying mantid. They have two pairs of wings and their forelegs are modified into a powerful vice for capturing and holding live prey.

Order 9. ISOPTERA—Termites, white-ants. Soft-bodied, winged or wingless. They are generally subterranean insects feeding on plants, timber, wood or other vegetable matter; they live in polymorphic social colonies and often raise large mounds of earth above ground.

Order 10. PSOCOPTERA—Booklice and barklice. They are minute, soft-bodied, winged or wingless, run and jump, and are found on barks and fallen leaves, and in old and damp books and paper.

Order 11. PHTHIRAPTERA—Biting and sucking lice. This order includes the head and body lice of man and monkey, and the bird lice. They are minute wingless, external parasites of birds and mammals that feed either on blood, feathers, hairs, scales, etc.

Order 12. THYSANOPTERA—Thrips. They are minute, generally heavily pigmented insects, with narrow membranous wings bearing a long marginal fringe of hairs and are commonly found in flowers.

Order 13. HETEROPTERA—Bugs. They are large and often hard-bodied insects, with the fore wings thickened and leathery or horny in the basal half but membranous at the tip; their hind wings are wholly membranous and head is produced into a beak which is specialized for piercing the bark of plants or skin of animals and of sucking sap or blood. Mostly terrestrial, many are aquatic and some like the bedbug are temporary parasites.

Order 14. HOMOPTERA—Cicadas, aphids, mealybugs, scale-insects. They are large and often also minute, soft-bodied insects with both pairs of wings membranous and head produced into a

sucking rostrum; sometimes wingless; and feed mostly on plant sap.

Order 15. COLEOPTERA—Beetles. They are large, small or minute, hard-bodied and often iridescent insects, with the front pair of wings modified into horny protective shells for the delicate and membranous hind wings. Beetles are vegetarians or omnivorous feeders and form the largest order of insects at present.

Order 16. HYMENOPTERA—Wasp, hornet, bee and ant. These insects have two pairs of membranous wings, of which the hind pair is always smaller. They are often social insects and hunters, vegetarians, carrion feeders, pollen or nectar feeders or also parasites.

Order 17. NEUROPTERA—Lacewing-insects and antlions. They are minute or medium-sized insects with both pairs of wings membranous and net-veined and are predators.

Order 18. TRICHOPTERA—Caddisfly. The caddisworm is the aquatic immature stage; it constructs cases of pieces of sticks, small stones and other suitable material, webbed together with silken threads and carries the case wherever it moves. The adult has two pairs of wings clothed with hairs.

Order 19. LEPIDOPTERA—Butterfly and moth. They are mostly large and brightly coloured insects, with two pairs of wings and long coiled proboscis fitted for sucking nectar from flowers, their body and wings clothed with thin, flat, minute scales.

Order 20. DIPTERA—Fly, mosquito, gnat and midge. Mostly small or minute insects, the species has only the fore wings and the hind wings reduced to knobbed stumps called halteres.

Order 21. APHANIPTERA—Fleas. They are minute, wingless jumping insects, with body compressed to facilitate moving among hairs of animals on which they are parasites; found generally on rat, dog, cat and other warm-blooded animals.

Order 22. THYSANURA—Silverfish-insect. Small, wingless running insects, their body is clothed with small silvery-white scales and generally occurring on rock, bark, behind pictures and among damp old books.

Order 23. COLLEMBOLA—Springtail and snowflea. They

are minute, soft bodied, wingless insects that jump by suddenly releasing the tail from between a clamp on the underside of the body. They occur in soil, moss and on the surface of tanks, lakes, ponds and snowfields.

The minor orders of insects, found in India, are Embioptera, Zoraptera, Grylloblattodea, Strepsiptera, Megaloptera, Mecoptera, Raphidiodea, Aptera and Protura. The order Diplogossata, ecto-parasitic on the Gambian rodents, does not occur in India.

CHAPTER II

INSECT WAYS AND FASHIONS

MARVELS OF INSECT FLIGHT

INSECTS ARE extremely restless creatures. Their physical activity and powers of endurance and flight are truly astonishing. They crawl, run about, dig underground, climb over smooth and polished surfaces that present no hold or grip, walk on the surface of water in ponds and lakes, dive or swim. Indeed they are always found doing something or other. Though apparently aimless, all their movements and actions are truly purposive. The most striking feature of their ceaseless activity is, however, flight. The entire anatomy of an insect's body is conditioned for this activity. Flight is the chief activity in the great majority of insects many of which feed and even mate and deposit eggs while in flight. The speed of insect flight varies between very wide limits. Some insects fly in a leisurely fashion, some flutter lazily about and others rush with great speed. The hawk-moths, which are the swiftest fliers, attain speeds of over 15 m per second and the dragonflies generally fly at speeds of 10 m per second. When in flight, most insects can suddenly arrest their motion, remain stationary in the air, reverse their direction and dart swiftly sideways.

The earliest animals on the earth to fly, the insects have perhaps the simplest and most efficient flight mechanism in the world. As a flying machine, their body is far more perfect than the best of man-made aeroplanes or birds. The wings are their organ of flight. Except in the generalized groups, the fore wings are larger than the hind wings. The two pairs of wings often differ in texture, shape, structure and other details. In some insects, the fore wings are modified into leathery or horny protective shields for the delicate hind wings which alone are used in flight. The surface of the wing is clothed with hairs and scales or ornamented by structural pits. In the fli s and in the mosquitoes, the hind wings are mere vestiges of knobbed stalks behind the fore wings,

and as such they have only two wings.

The wings of insects are essentially the expanded side lobes of the skeletal plates of the thorax. They are generally more long than wide, narrow at tip and attached to the body by a narrow base. The front margin of the wing is nearly straight and the hind margin is rounded. The wing membrane is reinforced and braced by a series of carefully placed veins which prevent its collapse and also serve to distribute properly the weight of the body when the insect is air-borne, thus effectively counterbalancing the complex tensions of wind, pressure, drag, etc.

In flight, the wings move rapidly upward, forward, downward and backward in a definite rhythmic sequence. The downstroke of the wing is accompanied by a simultaneous forward movement, so that the front margin of the wing is deflected and the hind margin turns upwards. The upstroke is associated with a backward movement and deflection of the hind margin of the wing. As a result of these complicated movements, the tip of the wing seems to describe a series of loops. In the movements of the wing are combined the actions of an efficient airfoil, propeller, steering mechanism, rudder and brake. The wing beats provide both the lifting force and the propelling power by creating a low pressure above the body of the insect and in front of it and at the same time high pressure below and behind its body. In insects which fly very fast the movements of the front wings create a turbulence behind them, and the hind wings, ingeniously coupled with the fore wings, are greatly reduced in size or are even absent. The frequency of the wing beats often exceeds one thousand times a second in Hymenoptera and Diptera. The wing of the male of the small fly *Forcipomyia* beats 988-1041 times a second. The familiar singing of the mosquito in the ear at night time, the humming of the bees (which gave them their name *bhramara* in Sanskrit) and the soft whirr of the moths are all the result of their wing beats with varying frequencies.

Wing beats are brought about by the rapid contractions of muscles in the thorax. It is paradoxical that in most insects practically no muscles are attached directly to the wings; the wings of

some of the best flying insects have no muscles at all. The wing strokes are actually brought about indirectly by the muscles of the legs that stretch from within the base of the leg to the upper skeletal armour plate of the thorax and by the longitudinal trunk muscles that pass from one segment of the thorax to the next. The wings are hinged in such a manner that the primary basal part of the leg acts as the wing fulcrum, and they are depressed by the arching up of the thoracic skeletal plate above and elevated by its flattening out. When the insect is on the ground, the contractions of these thoracic muscles move the legs when they walk, run or jump. When they are air-borne, the legs are tucked up and held stationary close against the body, so that the contractions of the very same muscles move the wings. The marvel of the whole series of events is the co-ordinated action of different muscles, varying widely in size, position, power, etc. This is rather an over-simplified description of the unique mechanism of insect flight; the reader interested in the complex modifications, specializations and precise aerodynamical sequence of events in insect flight must consult advanced works. It may, however, be said that there are still many unsolved questions concerning insect flight.

Food of Insects and How They Feed

The food and feeding habits of insects are no less interesting than their flight. Insects eat leaf, bark, twig, bud, flower, pollen grains, fruit, seed, nut and root of the higher plants, and moss, lichen and fungi and feather, scales, hairs, nails, hoof, skin and flesh of animals, including other insects. Their food includes all dead and decaying organic matter, dungs of various animals, timber, wood, cadavers, raw products of industry, manufactured goods, books, furniture, leather articles, wool, clothing, silk, cigar, cigarette, flour, bread, biscuit, dried fruit and nut and seed, chocolate, museum specimens and works of art, rubber and rubber goods.

Some insects are truly omnivorous and feed on a great variety of things; others restrict themselves to a few selected articles of food; and still others subsist exclusively on some preferred food. A great many species like the grasshopper are strictly vegetarians,

some like the dragonfly are carnivorous and others habitually feed only upon dead and decaying plant or animal matter.

The mode of eating is as diversified as the menu and depends on the nature of the food, the sex, age and class of the insect. In the course of development from the immature to the sexually mature adult stage, some insects regularly change from solid to liquid food, from vegetarian to animal food or even completely give up eating and are satisfied with swallowing air. There are two groups of insects, viz., those which bite morsels of solid food and chew them before swallowing and those which feed on liquids by puncturing or piercing the bark of plants or skins of animals and suck sap or blood. Some insects feed only in their immature stages and do not take any food at all as adults. The common mayfly feeds, for example, on algae, diatoms and other similar low aquatic vegetation only during its prolonged larval development in water. The adult mayfly which lives hardly for a few hours is quite incapable of feeding, but sometimes swallows air to increase the buoyancy which facilitates the nuptial flight. The caterpillar bites and chews solid morsels of leaf, bud, etc., but the butterfly into which it is eventually transformed sucks only the sweet honey of flowers. The larva of the mosquito often feeds on decaying organic matter and other minute particles suspended in water but the adult mosquito sucks blood. It may be pointed out that it is the female mosquito that alone sucks blood, and that the male mosquito either does not feed or may only sip plant juices. The larva of the common blister beetles sucks the eggs of various grasshoppers and bees, but the adult beetles feed exclusively on the tender petals and pollen of flowers.

Grasshoppers, cockroaches, many beetles and caterpillars of butterflies feed on solid food. Their mouth, lips and jaws are adapted for biting off morsels of food and chewing them to a fine pulp before swallowing. The upper (mandible) and the lower (maxilla) jaws of these insects are armed with powerful teeth to bite and crush hard solid masses of food.

In insects which feed on liquids, the upper lip (labrum) and the lower lip (labium) are produced together into a beak and the mandibles and maxillae are elongated and modified into sharply

pointed needles or stylets for piercing the epidermis of plants or the skin of animals. The mouth cavity forms a powerful sucking pump. The bed-bugs, butterflies, honeybees, mosquitoes and houseflies are among the insects which feed on liquids.

In the bed-bug *Cimex rotundatus* the beak (also called rostrum) is composed of the elongated labrum and labium and encloses two pairs of piercing stylets. One pair is the greatly elongated and modified mandibles. The other pair is the similarly modified maxillae, which are also grooved inside and together make the sucking tube. In the butterfly the parts of the mouth are modified into an extraordinarily elongated proboscis which is much longer than the body of the butterfly and which is kept coiled under the head when not in use. This proboscis is adapted to reach down to the bottom of the tubes of long flowers, puncture the nectaries concealed therein and suck the nectar. It is the modified maxillae. The mandibles are absent in the butterflies, since they do not have to chew solid food. In the honeybees the mandibles are smooth and toothless and are suited for manipulating the bees' wax while building the honeycombs. Their maxillae are modified into sharp scalpels for puncturing the nectaries of the flowers and the tongue which licks the nectar is the modified labium. In the female mosquito the labrum, mandibles, maxillae and labium are all modified into needles. The housefly licks its food from moist surfaces with the help of its haustellum or the modified labium, much in the same way that a sponge absorbs moisture.

The food is digested in the gut by the action of digestive juices and enzymes, as in the case of man and other animals. Some insects can readily digest apparently indigestible substances like cellulose and wood. In the case of insects like the termites, which feed on wood, it is digested and converted into soluble sugars with the help of certain friendly micro-organisms that live in their gut. These organisms have the necessary enzymes for converting the cellulose of wood into sugars for their own use and the termite absorbs this sugar into its blood. Certain blood-sucking bugs like the assassin-bug have special spaces for containing bacteria which partially digest the blood meal for the bug.

INSECT HUNTERS, FREE BOARDERS AND PARASITES

Although insects are capable of eating almost anything, it must not be supposed that on this account they lead a lazy life. Each species has its own special nutritional requirements and tastes for preferred food which may not be easily obtainable. Like every other animal, insects have to work hard for a living and yet they barely succeed in getting enough to eat. They have actively to search for food, gather it laboriously, prepare it carefully and store it for use during times of scarcity. Many species go forth in search of food and eat it wherever and whenever they find it, but most others transport it first to a place of safety to be eaten later at leisure. Other species cultivate their food requirements, which include a special kind of grass or fungus. Still others are hunters which locate, stalk, overpower and capture their prey, and process it before consuming. A large number steal their food from other insects as a matter of course. A whole group of insects do not trouble themselves to gather or store food, but consider themselves as uninvited guests of other species.

The Hunters and their Strategy—Hunting live prey is so widespread among insects that it almost seems that they are always busy killing each other. The worst enemies of insects are insects themselves. While many hunt for worms, slugs, snails, spiders and even smaller lizards, birds and mammals, the worst victims are other insects. Nearly every species is hunted and devoured by some other species. The dominant predatory species belong to Plecoptera, Odonata, Mantodea, certain Hymenoptera, Coleoptera especially the Carabidae, certain Heteroptera and many Diptera.

The hunting technique of different species varies according to the nature and the size of the prey and local conditions. Nearly all the predatory insects strike with lightning speed. They invariably possess great physical strength and often show much cunning in locating, stalking and overpowering their prey. Some predators locate prey and pursue it by scent and others, especially the winged ones by sight. Their compound eyes are exceptionally well developed and often occupy the whole visible surface of the head. They can easily perceive even slight movements in the field of their vision.

While a prey remains comparatively safe from attack as long as it remains motionless, its slightest movement seals its fate.

While some hunters actively chase the prey, others lie patiently in wait for some luckless victim that chance may bring within their grasp.

Active pursuit of prey—Active pursuit of the prey by an insect hunter may be on the ground or in the air. The ground beetles (Carabidae), the firefly (glow-worm) (Lampyridae) and many digger wasps run down their victims on the ground. The prey is caught in the powerful mandibles, torn to pieces and devoured. Dragonflies are perhaps the most powerful of winged hunters. While flying swiftly, they catch mosquitoes, gnats and midges with the help of their spined legs which form a sort of loose-mesh basket. The robberflies (Asilidae) capture houseflies, mosquitoes and other smaller flies in flight and suck them completely dry. Many hornets and solitary wasps locate a prey, which may be a spider or a cricket lying concealed in its den. They dig down to reach it or entice it by various strategic movements or drive it out of its shelter by threats, drag it to the open ground, paralyse it by stinging it and carry it off to their nests.

Lying in wait for an unwary prey—Many insects remain motionless, often assuming a most innocent-looking and innocuous posture, in a place usually frequented by the prey and expertly capture the unwary ones that come within striking distance. The praying mantis has a long slender thorax and a head that can be turned easily in any desired direction, without fear of dislocating the neck and without having to alter the position of the body. Its forelegs are long and powerful and are armed with stout and sharply pointed spines and teeth. When folded, the fore legs form a most formidable vice, escape from which is impossible. When waiting for its victim, the motionless and inconspicuous mantis holds its fore legs close to its body, raised forward and assuming a grotesque posture, as if to say prayers with folded hands—hence the name praying mantis. It is, in reality, a 'preying' mantis. Any insect, or an animal, including a lizard, or a small bird, or even another careless mantis that may accidentally come close is snapped up by the forelegs with the speed

of lightning—and held pinned between terrible teeth and spines. The struggling victim is then calmly devoured bit by bit, till it is entirely consumed.

The aquatic larva of the common dragonfly has its labium modified into an elongated and beautifully hinged trap, called fangmask. The larva waits motionless, half buried in the mud, with the fangmask tucked neatly under the head and looking perfectly harmless. As the prey comes within striking distance, the fangmask suddenly shoots out and pins it within the toothed claw-like tip.

The larva of the common antlion *Myrmeleon* goes a step further. It does not wait for a prey to come by chance but resorts to trapping it in specially constructed pits. The antlion larva, true to its name, is a terror for ants on which it feeds exclusively all the year round and throughout its life. As we know, ants are busybodies who go about as if in a great hurry, bump into each other, stumble over obstacles, fall into pits, get out quickly only to move again as if nothing had happened. The wily antlion takes mean advantage of the habits of ants. It digs a conical pit in loose soil or sand, frequented by ants, and lies hidden at the bottom of the pit, with just the tip of its sharp and pincer-like mandibles exposed ready for action. An ant which moves about in a hurry suddenly slips and falls into the pit, gets panicky and makes a frantic attempt to climb out, but in vain, because the loose and rolling grains of sand make it slide down further. The antlion, waiting patiently and expectantly for this very opportunity, drags the ant under the sand and sucks its blood and body fluids in full.

Free lodgers and Free boarders—Perhaps the easiest way of earning your living is to go to the home of someone pretending that he is your particular friend. You need not of course worry about how your "friend" feels about you. A number of insects do the same thing; they have even refined it to an art. Some go about the job in a casual way and do not mind being thrown out unceremoniously by the irate "friend". Others are unwanted guests in the nest of another insect, not for a few hours but for a whole life-time and even for generations.

Most insects appear to choose a home for free lodging and free

boarding with extraordinary care, so as to ensure that they are not thrown out by the owner as a *persona non grata;* they even take the trouble of ingratiating themselves with the host. Now, where are you likely to be treated well, even though you are a perfect stranger ? The answer is simple: it is in a house where a wedding takes place, where there is much bustle and noise and people hurry about doing nothing useful. The bride's party takes you for one of the bridegroom's party and the bridegroom's party takes you for one of the bride's party and you merrily get along with both the parties. In the crowd, the confusion and the bustle lies your opportunity.

In the nests of termites, ants and social wasps too, the same conditions prevail. They are usually crowded with hundreds, nay thousands, of busy individuals, each of whom is engaged in a variety of tasks and is always rushing in and out. They do not have the time to notice an unobtrusive intruder. Their nests are the favoured resorts of whole groups of uninvited guests like crickets, certain beetles (Paussids, Staphylinids), caterpillars of Lycaenid butterflies, Phorid flies, etc. These, are therefore, known as termitophilous (termite-loving) or myrmecophilous (ant-loving) insects. They feed on the rich and varied food gathered and stored by their hosts and also on food left over or rejected. Some of the myrmecophilous insects have even adopted the postures and gaits of the ants among which they live; many of them indeed look so like ants that even trained entomologists may mistake them at first sight for ants.

Parasites—A parasite lives on or inside the body of another organism, its host, and depends on it for shelter and nourishment, but it gives nothing in return. In a socialist country it would be accused as an enemy of the proletariat. The parasite has no separate and independent existence from its host. Unlike the predator that kills its prey outright, a parasite carefully avoids killing the host in the beginning, but feeds unobtrusively and gradually. The death of the host may occur eventually after the parasite has completed its full course of development; the parasite mercifully spares its victim till its own purpose is fulfilled. Some species of insects are occasionally parasitic and at other times independent. The bed-

bug is, for example, an occasional external parasite on man, most of the time it hides in cracks and crevices and comes out to suck human blood only at nightfall when it is hungry. Other species like the lice *Pediculus humanus* are external parasites on the head or body of human beings throughout their life and cannot survive without man. Although parasitic insects attack nearly every group of animals, it is an irony that other insects are their most common hosts. The insects which parasitize other insects are known as *entomophagous* parasites.

Nearly every species of insects is subject to the attack of one or more species of parasitic insects. An insect parasite of an insect is in its turn attacked by another parasitic insect—a hyperparasite or a parasite on a parasite.

It is curious that most entomophagous parasites are parasitic only in their larval stage; as sexually mature adults they are most often winged and lead a free and independent life. Parasitic insects attack all stages of the host insect—its eggs, larvae, pupae and adult. Although parasitism is met with in many orders of insects, Hymenoptera and to some extent Diptera stand out as the dominant entomophagous ones. Many Hymenoptera like Ichneumonids, Braconids, Evaniids, Chalcidoide, etc., parasitize the eggs and larvae of nearly every group of insects. Most entomophagous parasites show more or less decided preference for specific hosts. For example, the Evaniids exclusively parasitize the eggs of cockroaches. *Evania appendigaster*, the ensignfly (so called because it waves its flat abdomen up and down like a flag) is an egg parasite of the common cockroach *Periplaneta americana* throughout the world. The tiny metallic-green Chalcidoid *Podagrion* is an exclusive parasite on the eggs of praying mantids.

Insect Proletariat, Royalty and Caste-dominated Socialist Automatons

Equality is perhaps an unattainable ideal and in the final analysis undesirable. In a group of animals in which the giants are over three hundred times the size of the dwarfs, in which the "have-nots" seek free lodging and free boarding from the "haves", and in

which a few hunt and many are hunted and no species is free from the attack of a parasite, some members must inevitably be "more equal" than the others. Among all insects, the female is more equal than the male, who is often under many disadvantages and who is more often than not ill-treated, denigrated and even eliminated. Insect society is basically a society of women, run by women for women, one in which the male is a misfit. The female does all the work and the male is ignored and is an ignoble dummy. Inequality of capacity performance, preference, status, reward and opportunity is the most outstanding feature of insect societies. Most insects toil ceaselessly to earn their livelihood and to maintain a few in comparative luxury and idleness. The insect toilers forage, cultivate crops, harvest the grain, scavenge and clean their homes; or they are masons, builders, carpenters, weavers, if not soldiers. There is a rigid caste system which is based on the work undertaken, and from which escape is out of the question. The labours of the exploited toilers contribute to the common good of the whole community—the products of labour belong not to the toiling individual but to the community. Though rigidly caste-ridden and founded on fundamental inequality, it is a kind of socialism into which even royalty is accommodated. The privileges of royalty are in no danger of being abolished in the socialistic pattern of insect society; however, royalty is maintained not for its own sake but because it is indispensable to the community.

The social insects are the termites, wasps, bees and ants. The termite colony may consist of a few million individuals divided into various castes, viz., sexually sterile females or workers, soldiers, males or kings and one sexually fertile female or the queen termite. The individuals belonging to the different castes are readily recognized by the pronounced differences in the size and shape of the head, sense organs and other parts. The queen termite and the king belong to the reproductive caste. The queen termite is an enormous, elongate, fat wormlike creature, often as long as 10 cm. She lives up to fifteen or even fifty years.

The sexual forms are winged at first and have compound eyes. They swarm in large numbers, usually after the first monsoon rains.

After swarming, they shed their wings and mate. The males then perish, but the females become the fat queen termites which establish new colonies. In many cases there are two types of reproductive castes—the primary and the supplementary. The winged adults that give rise to the fertile and sterile progeny form the primary caste. Those forming the supplementary caste never become aerial and generally have reduced eyes and wings. The sterile castes include the workers and soldiers, all of whom are wingless and blind and have the sexual organs atrophied or absent. The workers are the most numerous members in a termite colony. They ar pale in colour, soft-bodied and blind, but with well-developed mandibles. The workers forage, feed the queen, care for the eggs laid by her, tend the newly hatched young, cultivate special food fungus, excavate the underground nest or inside wood, build earthen mounds above ground and do all other work of the colony.

The soldiers who form highly specialized castes have either an extraordinarily massive and hard head provided with enormously developed and pointed mandibles or an elongated head pointed into a beak. The soldiers may be males or females. The pseudergates are the blind young which often carry on the duties of the true workers; they are a kind of casual labourers. The termites usually inhabit underground galleries, often with huge mounds that are six metres high above the ground. Some termites live in wooden structures. All termites feed on plant parts, living or dead, cultivate a special fungus as food, and also regularly devour the excreta, skins and the dead bodies of other termites. They digest the wood and cellulose of plant material with the help of certain protozoa, which live as friendly organisms inside their gut. Termites are perhaps the most destructive to vegetation in the world, but they help in reducing dead vegetation and thus enrich the soil.

The termites are also the most prolific among insects; a single queen termite may lay up to 15,000,000 eggs during her lifetime. The founding of a new termite colony is initiated by swarming. Great numbers of the primary reproductive castes issue forth through holes from the old nest or mound in a continuous stream of males and females. They fly in swarms, which are attracted

strongly to light. Their flight range is, however, not much; the swarms of *Kalotermes* fly about three-fourths of a kilometre; others hardly fly a few metres from the old nest. The swarms pay a very heavy toll to frogs, lizards and birds. Ants are also their implacable enemies. After the nuptial flight, the wings are shed and the male follows the female to some suitable underground nuptial chamber for mating. The primary queen in a new colony at first lays about fifty eggs and later on several thousands a day. The fertile queen starts reproducing without acquiring any of the secondary external features of an adult.

Termites have numerous enemies. Among them are the ants, frogs, etc., already mentioned, the Australian spiny ant-eater *Echidna*, the Indian pangolins, the South American *Myrmecophaga*, etc.

The nests of termites contain, in addition to the numerous individuals belonging to different termite castes, countless numbers of termitophilous insects like springtails, silverfish-insects, crickets, various beetles and flies that live as guests. There are also many kinds of parasites of the termites and of the termitophilous guests.

It must be mentioned at this stage that the great numbers of the inhabitants of the termite colony are really the progeny of a single female; a termite colony is essentially an overgrown family of sisters and brothers.

The Honeybees—The honeybees are social bees of which we know four species, viz., *Apis mellifera*, *Apis indica*, *Apis dorsata* and *Apis florea*. They build combs of bees-wax secreted by the worker bees and gather pollen and nectar from flowers. Their tongues are elongated and modified for reaching down to the bottom of flowers and to rupture the nectaries. Their hind legs are hairy and form a brush for collecting pollen grains and also a basket for transporting them to the nest. In Nature, the honeybees build their combs on branches of trees, in hollows in tree trunks or overhanging ledges of massive rocks. The domesticated honeybees build their combs on movable wooden frames which are arranged in rows inside wooden box hives.

In a bee colony we find one sexually fertile female, the queen bee,

and a few sexually fertile males or drone bees and numerous sterile females or worker bees. The fertilized queen bee founds the colony; she lays a few eggs and nourishes the newly hatched young with her own saliva till the first workers emerge. The latter then completely relieve her of the labour of looking after the young ones, so that she is free to devote her energies and time to egg-laying. The workers enlarge the nest, feed, clean and care for the young, defend the nest against intruders, go forth in search of pollen grains and nectar, etc. The drones merely idle away their time, feeding and waiting for the nuptial flight of a newborn queen. When the colony becomes large and overcrowded, the workers feed a young one which in the ordinary course would develop into a sterile worker, with a special kind of food. Upon this feeding, the young develops into a new queen. She leaves the nest with a swarm of workers. The drones follow her out of the ancestral home for mating. A point of great interest is that among the honeybees the fertilized eggs develop into females and the unfertilized ones into males.

The Ants—The ants are perhaps the best known and the most widely distributed among the insects. They occur in the forest, in grass-lands, deserts, tropical, temperate and arctic regions, on the Himalayas. All ants are social; solitary ants are unknown. No ant can survive for long away from its society. The social life of the ants is far more complicated than that of the bees or the termites and presents many unsolved problems for the naturalist. The size and the polymorphism of the ant colony are extremely variable and bewildering.

Polymorphism attains perhaps its maximum development and complexity among them; as many as twenty-one different castes may be found in the colony of a single species of ants. An ant colony contains usually the following castes: (i) gynaecoid workers capable of becoming queen ants if well nourished; (ii) numerous workers, which are of course sterile females, wingless and of diverse kinds; (iii) soldiers, which are peculiarly modified workers with enormous heads and terrible jaws, armed with sharp teeth for crushing a foe; (iv) fertile females, which are large and winged; (v) fertile males. The queen ant, once fertilized by the male in

the nuptial flight, sheds her wings which are now useless and rears her first brood of young by feeding them with a special secretion of her own saliva. As soon as the first workers appear from this brood, they go forth for forage and take over from her the responsibility of looking after the young ones. The queen ant thenceforward concentrates on egg-laying and continues to do so for about fifteen years. An ant colony may contain over half a million individuals. Ant nests are built underground, on trees, in hollow stems, thorns, fruits, among leaves, etc.

The common Indian *Oecophylla* webs the leaves of mango, thespesia and other plants into a nest, using the silken threads produced by the larva, which is moved deftly by the worker right and left. This ant ferociously attacks those who intrude into the tree on which it

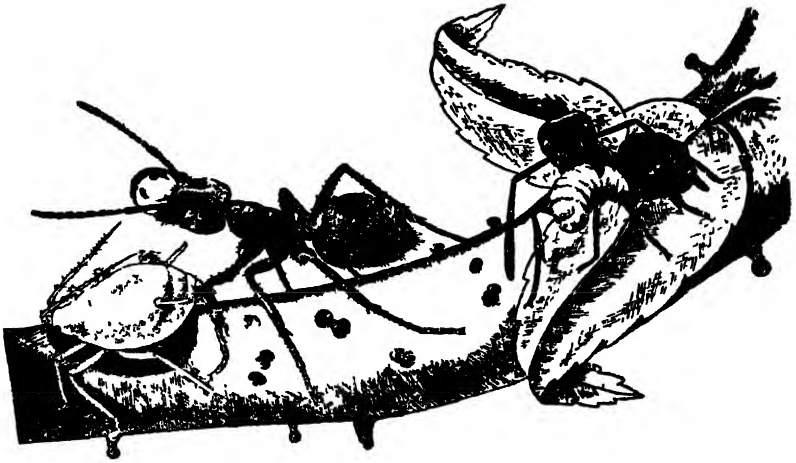

FIG. 1— The busy ant. On the left an ant worker has just "milked" the ant-cow aphid for the glistening drop of sweet honeydew, now held between its jaws ready for swallowing. On the right, a worker is carrying a larva.

has made its nest and squirts an acrid formic acid secretion at them from a distance.

The vegetarian ants feed on seeds, leaves, fungi or nectar. Many

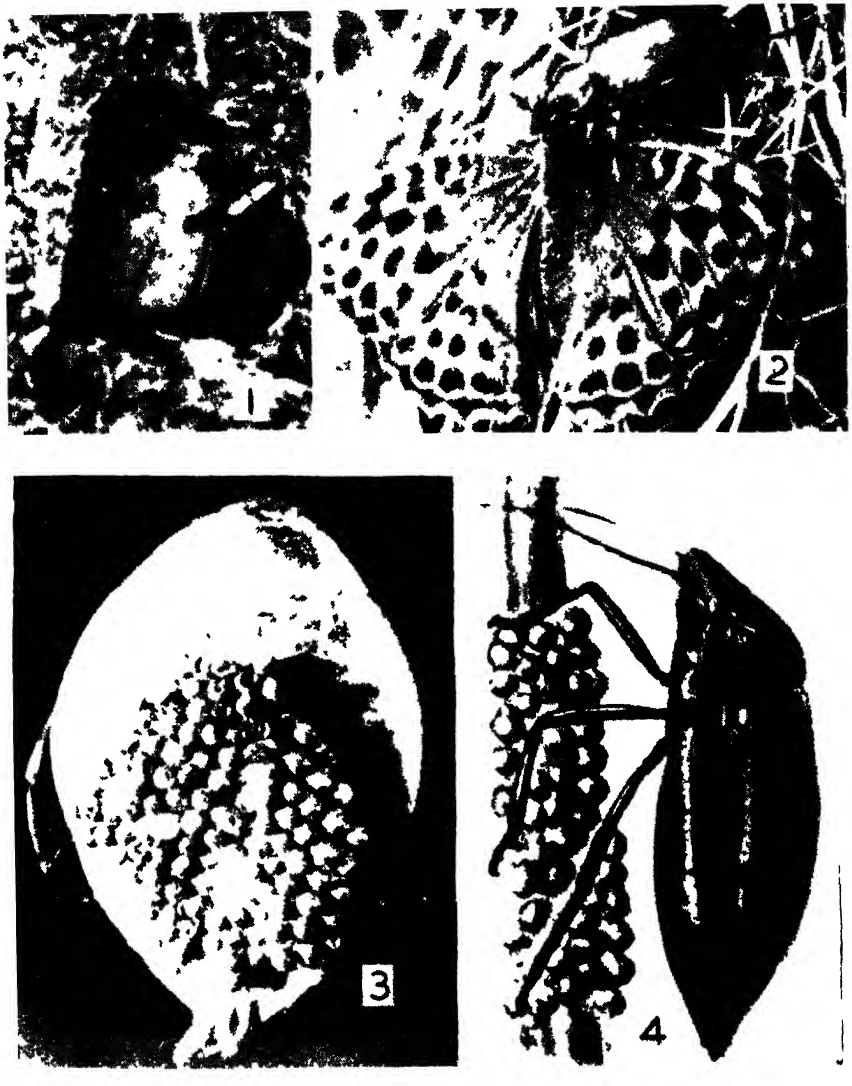

PLATE I Ground-beetles. 1 A common ground-beetle *Calosoma* at its underground burrow. 2 *Calosoma* feeding on an adult butterfly it has caught resting on the ground. 3 A male of the aquatic bug *Sphaerodema* carrying the eggs, laid by his wife on his back: he serves as a living incubator-cum-perambulator for the eggs. 4 One of our common Pentatomid bugs standing guard over her cluster of eggs, which she has deposited on a twig; she threatens and drives away any intruder and leaves off only after the young have all hatched from the eggs.

PLATE II Mounds erected by termites above their subterranean nests, such mounds are true sky scraper cities of termites taller than an average man and constitute typical landmarks of South India (Photo reproduced by courtesy of the Zoological Survey of India)

PLATE III 1 Ootheca of common praying mantis, fixed to branches of a bush it forms an effective therma-insulator of solidified foam for the eggs laid in the middle 2 The mud pots of *Rhynchium*, with the wasps busy giving the finishing touches to the pots. When completed and filled with eggs and store of larval food the wasp smears sticky gum on the outside as a protection against the attack of enemies. 3 The common potter wasp *Eumenes* completing the rim of her pot attached to a grass stem, a completed pot is below

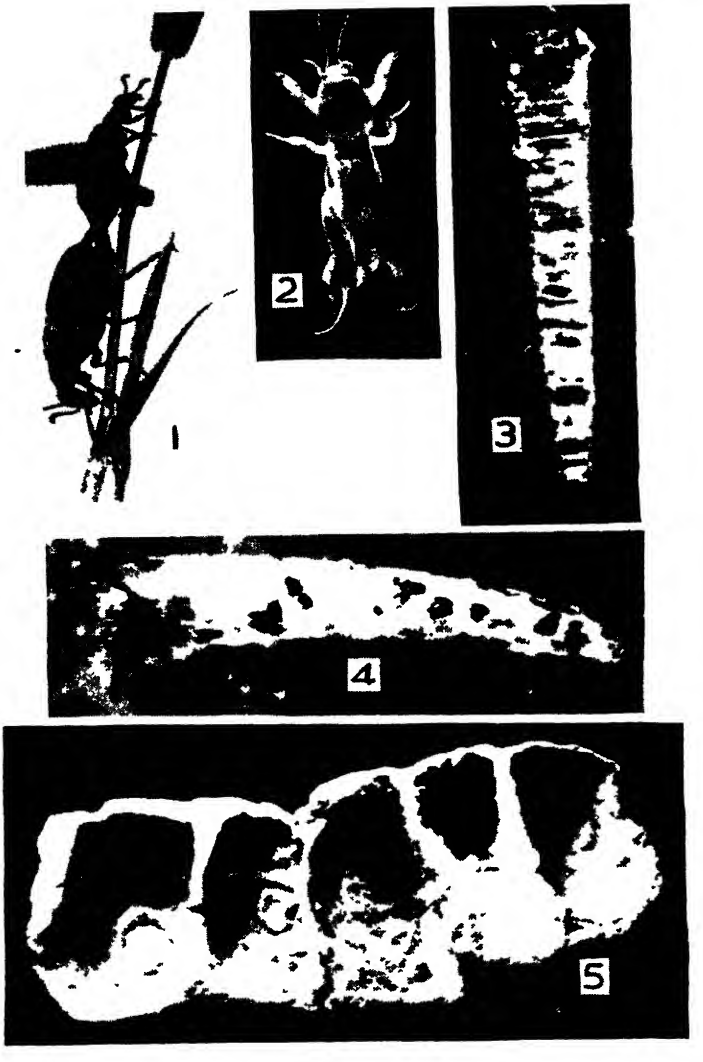

PLATE IV. 1. The common blister beetle *Macrabris pustulata* mating on a grass stem; the smaller male beetle is above, the lower larger one is the female 2. The male cricket *Gryllotalpa*, an expert and powerful digger, which spends the daytime in its underground burrow and comes out at night. It establishes its brood nest in its own living quarters, after suitably enlarging and modifying it. 3-4. Caddisfly larval cases of pieces of sticks and of sand and small pebbles. 5. The interior of a series of mud pots of *Eumenes*, showing the caps.

ants like the agricultural ant *Holcomyrmex* regularly cultivate various kinds of grasses and herbs and when the seeds are ripe harvest them. When the rains come, the workers sow the seeds around their nests. After the harvest, they nearly pile the sticks and chaff in a circle around the nest entrance. Most ants tend aphids, membracids, etc., and feed on the sweet honeydew secreted by them. The ants belonging to the tribe Attini cultivate a cherished food-fungus on a prepared culture medium bed inside their nests. The culture bed is made of leaves. The workers emerge from the nest early in the morning, climb a suitable tree or shrub, cut the leaves into pieces and drop them to the ground, from where other workers carry them to the nest. The pieces of leaf are held aloft above the head like an umbrella, so that the worker may run freely and reach the nest with the least delay. At the entrance to the nest, a relay of other workers relieves them of their load and takes the pieces inside, and piles them one over another, in specially prepared cells. A band of workers now brings the seed-spores of the fungus and inoculates the culture bed with them. Any foreign fungus that may appear as weed is promptly removed. The ants feed on the fruit bodies of the fungus. The workers of the honeypot ant *Meloporus* have immensely swollen bellies, which serve as living pots to store honey for the use of the whole colony. The slave-driving ants invade the nest of other species, overpower them in a bitter fight, enter the nest and triumphantly carry off their young ones. The workers, which develop from the captured larvae, become the slaves of their masters who cannot feed unless a slave is at hand to put the food into their mouth.

The ant nest contains numerous uninvited, ignored, and even unwelcome guest insects, such as crickets, aphids, membracids, coccids, flies, springtails, etc., in addition to parasites and other visitors. There are also antlike spiders that live regularly inside the ant nest.

Courtship and Reproduction

The sexual life of insects is as full of marvels as the other aspects of their behaviour. Like most higher animals, there are two sexes, the proportion of the males and females being usually almost equal.

In some species, however, there is a great preponderance of females over the males and in a few the males are extremely rare or almost absent. In a number of insects the females are capable of laying eggs even without mating, so that the males are either unknown or they may appear at long and irregular intervals, perhaps after many generations of females. Certain races of the stoneflies are hermaphroditic. Usually the two sexes differ considerably in size, colour and other characteristics, so that the sex dimorphism is more or less pronounced; the female is usually larger, with better developed sense organs. The female usually lives longer than the male. While the adult female of many insects takes food, the male is incapable of feeding. We have already pointed out that it is the female of the mosquito that is alone capable of biting man. The female of the case-bearing Psychid moths is a completely wingless and grublike creature and only the male has wings. In the fig insects inside the fruits of fig trees, the male is wingless, whereas the female is winged. The female of the so-called velvet-ant (Mutillid wasp) is wingless, while the male is winged and does not resemble the female. The female of certain gall-making cynipid wasps is winged only in alternate generations.

There is usually some kind of courtship before mating. The males wave their antennae, beat their wings, stroke the female and show other signs of excitement. In a number of insects like the mayfly, dragonfly, termites, etc., large swarms of females and males dance on wings in the air. Individuals in the swarms soon rise higher and higher in pairs. During courtship the male of certain scarabaeid beetles gathers the food of the future larva and presents it as a love offering to the female. The male also lends a hand in the preparation of the nuptial chamber; sometimes he prepares it all by himself beforehand and then proceeds to invite his lady love into it.

A number of insects mate in mid air at the end of the nuptial flight when the females and males rise as high as they can in the air. Others crawl in pairs into a suitable shelter, such as under a stone. Still others mate among leaves, bushes, grass, etc., or even on the ground. At the end of the mating the males usually become exhausted and die. The fate of the male

praying mantis is most unenviable. Even as he is in the highest ecstasy of mating, his spouse devours him.

Reproduction is bisexual in most insects. As already mentioned, the unmated females are also often capable of successfully reproducing and depositing completely viable eggs that develop into normal insects. Such a mode of reproduction by a virgin insect is known as parthenogenesis; it is very common in many orders and a regular event in alternate generations in certain orders. Parthenogenesis alternates with bisexual reproduction in the aphids and gall wasps. The unfertilized eggs develop usually into males and in many cases the fertilized eggs into females. This is, for example, observed in cynipid wasps and in the honeybees. In the aphids the reproduction is often extremely complex. From a fertilized egg develops a wingless female that reproduces parthenogenetically for several generations, the numerous progeny being wingless females. Then appear both females and males, again by parthenogenetic reproduction. These females and males now migrate to another food plant, mate and the females deposit fertilized eggs. Among certain Diptera, in addition to the sexually developed female adult, the immature larva is capable of reproducing parthenogenetically. This phenomenon of reproduction by the young is known as paedogenesis and is met with in *Miastor* snd other gall midges. The number of eggs deposited by the female varies from one to several million. In viviparous insects, the eggs hatch within the mother's body and larvae or pupae or the young adult are born. There is in some viviparous insects a well developed uterus, from which the young insect derives its nourishment for development.

Metamorphosis—The development of the egg is usually rapid. When the young hatches from the egg, it does not resemble the adult; it is usually an immature and wormlike creature called a larva, without wings, and often without compound eyes and antennae. The larva feeds voraciously and moults its skin a few times during its growth. When fully grown, it stops feeding, becomes sluggish, seeks some sheltered place and often spins a protective cocoon of silken threads. It moults once more and is transformed

into a motionless, non-feeding pupa. After a period of apparent quiescence, the pupa moults and out of it emerges the winged adult insect—a beetle, a butterfly or a fly, as the case may be. This transformation of a larva into an adult insect and the series of changes undergone by the larva before becoming an adult are known as metamorphosis. In some insects like butterflies, beetles, bees, wasps, ants, mosquitoes and flies, the transformation of the immature larva into the winged adult insect takes place abruptly in the pupa. Their metamorphosis is described as complete. The orders of insects which undergo complete metamorphosis are placed in a division called Holometabola. In other insects like grasshoppers, cockroaches and bugs, the appearance of adult features is rather gradual, the wing rudiments are present even in the early larval stages, but become progressively larger at each successive moulting and there is also no quiescent stage of pupa. Their metamorphosis is incomplete and they belong to the division Heterometabola. The course of metamorphosis is influenced by many factors, including the external conditions of atmospheric temperature, humidity, food and hormones produced in the brain of the insect itself.

It is most fascinating to study the sudden transformation of an apparently ugly caterpillar, disfiguring the leaves of our garden plants into the gorgeously coloured butterfly that flutters from flower to flower. As one watches the miracle of the limp butterfly breaking out through the skin of the pupa, slowly spreading out its wings, waiting for them to dry and harden and then flying unhesitatingly to the nearest flower, one is faced with many unanswered questions——how do butterfly wings come into being? How does the newly emerged butterfly know that it should fly to a particular flower for nectar? Why does it undergo metamorphosis? Here is an endless field of study and entertainment.

CHAPTER III

CHILD WELFARE IN INSECTS

INSECTS, like all other animals, face starvation, exposure, diseases, natural enemies and numerous other dangers. The adult insect is usually capable of moving from place to place, finding its food and avoiding dangers. It can also face its enemies and generally take good care of itself. The eggs and the larvae are, on the other hand, mostly helpless. During the period of incubation, the egg is exposed not only to dangers like frost, heat, excessive moisture or dryness, but also to numerous enemies. The young larvae have also to find shelter and food. Many of them lose their way, and eventually succumb to hunger and fatigue, others fall victim to ruthless enemies. When the hazards are taken into account, it is indeed a marvel that these creatures survive at all.

In all animals, the parents generally guard the young from danger, shield them from exposure, feed them, educate them and care for them till they are able to fend for themselves. It is this parental care that largely minimizes infant mortality in animals.

Most insects are, however, orphans at birth, their fathers having died soon after marriage and the widowed mothers following him after depositing eggs. Though the vast majority of the

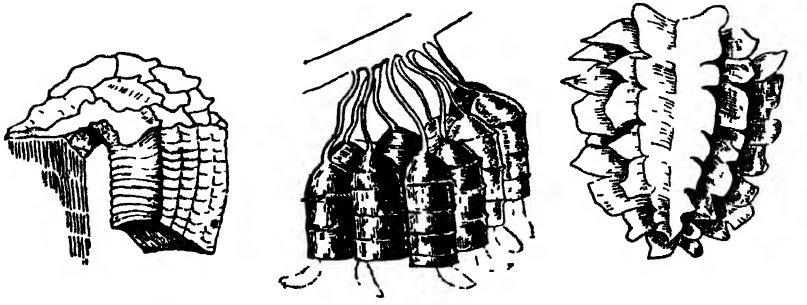

FIG. 2—Different egg cases of casidid beetles

insects thus never live long enough to see their offspring, parental care is known in nearly all of them. In some there may be merely the suggestion of care for young, but in others there is a relatively high degree of parental solicitude. It extends to all stages: the eggs, larvae, pupae and even to the newly emerged young adults.

Care of Eggs

The insect mother carefully deposits eggs in the correct medium and in such places as give maximum protection against adverse climatic conditions and enable the freshly hatched larvae to find food and shelter without much difficulty. It resorts to concealment of the eggs from enemies.

Oviposition is not a haphazard performance, but involves varying degrees of anticipatory care. First comes the finding of the correct medium in which the eggs must be deposited. Many aerial insects have, for example, aquatic larvae, and as such they have to deposit their eggs in water. The adult caddisfly, stonefly, dragonfly, mayfly and the mosquito which do not live in water nevertheless unerringly find a pond or a stream, according to the particular habits of the larvae and deposit their eggs either in the water itself or in the immediate vicinity thereof. The eggs are not scattered loosely; various methods are adopted to secure firm anchorage, so as to prevent them from being sunk or washed away by currents, and to minimize damage from other causes. The eggs laid on the surface of a pond or tank are in danger of drowning and to avert it the mother insect prepares egg rafts. Many insects, which ordinarily deposit eggs on the leaves of trees during spring and summer, take in autumn the additional precaution of also fixing the leaf to the twig with a hard secretion, so that the leaf with the eggs may not fall to the ground. The habit of providing the eggs with shelter against adverse climatic conditions and actively concealing them from their enemies, is widely met with. Some insects bury their eggs underground; others thrust their eggs into the ground. Grasshoppers often push the eggs down to great depths in soft soil with the help of their extensible abdomen. The tiger beetles excavate tubular tunnels in the ground, lay eggs at the bottom,

carefully refill the tunnel with mud and even take the trouble of smoothening the surface of the ground, so as to leave no tell-tale marks. Some insects go to the extent of opening up a false tunnel after closing the real egg chamber, with a view to confusing a possible enemy. While some insects cover their eggs with bits of dirt, faecal pellets or special secretions like wax, and silken threads often mixed with foreign matter, others laboriously prepare egg cases, egg rafts, egg cocoons, etc., in which the eggs are laid. The construction of such oothecae or egg cases is often not merely an attempt to conceal the eggs after they have been deposited, but an elaborate preparation in anticipation of their arrival. Every conceivable material is pressed into service in making the ootheca. The beetle *Aspidomorpha miliaris*, common throughout India on *Convolvulus* plants, constructs an ootheca for about 30-80 eggs, with eight longitudinal rows of cells, of which only the four middle cells really contain the eggs and the other two on each side are empty, to serve as protective buffers. It takes about an hour and a half to make one ootheca; a female usually prepares as many as seventy oothecae during her lifetime. The praying mantis, to which we have already referred as a murderous wife, is nevertheless an ideal mother; she prepares a great variety of oothecae for her eggs from a special secretion. The ootheca of the praying mantis is essentially an air-filled solidified foam that serves eminently as a therma-insulator for the eggs. It is usually prepared at night and fixed prominently to some branch of a bush. Hydrophilid water-beetles prepare complicated egg rafts of silken webs and even provide a ventilator tube for the eggs inside. The female gets below a floating leaf and holding its edges by the front legs, begins to web it. Ten minutes later, it does a somersault and floats upside down, still holding on to the leaf. In this position, it continues to web the leaf margins together. A spacious pocket is thus formed, into which the eggs are then thrust. A vertical and somewhat chimney-shaped ventilator piece is then added for conveying air to the eggs. The finished egg raft is finally camouflaged with odd

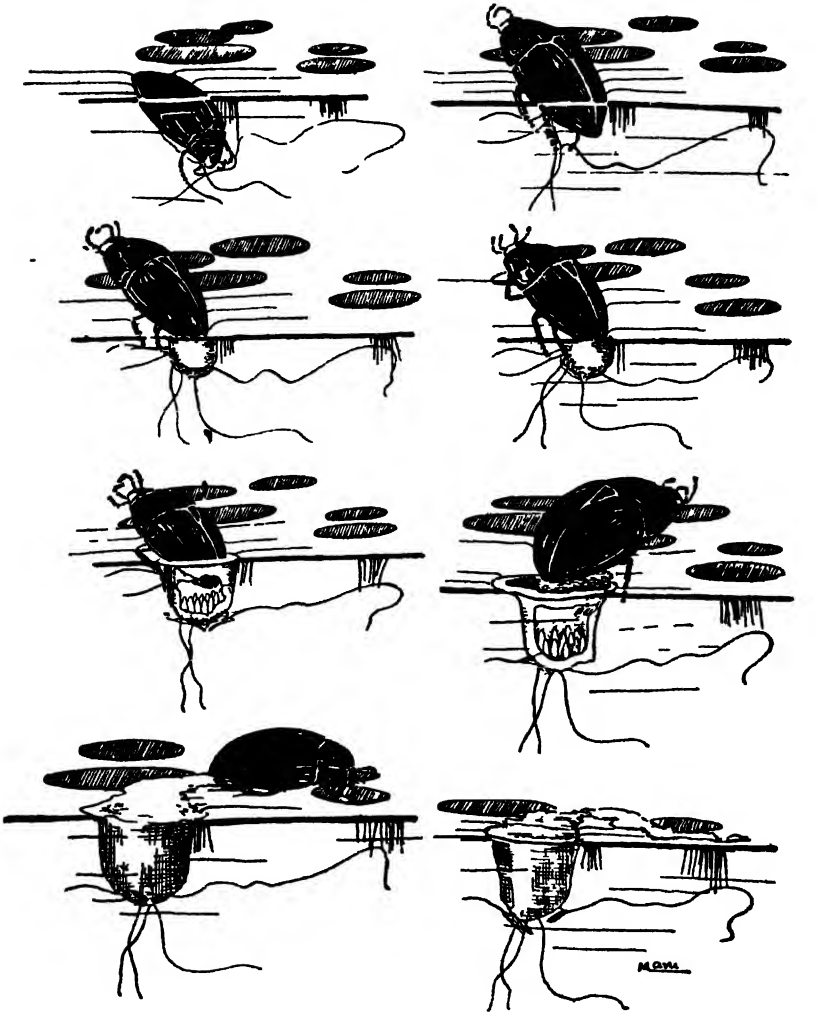

FIG. 4—The female aquatic beetle *Hydrous* and its egg cocoon of silken threads, prepared under a floating leaf and provided with a short, curved ventilator tube for conveying air to the developing eggs inside. Sometimes the cocoons are cleverly camouflaged with the leaves of duckweed and other water plants, stuck on the surface at strategic places.

bits of leaf of the duckweed, stuck here and there, to ensure that no portion of the egg case is seen on the water surface.

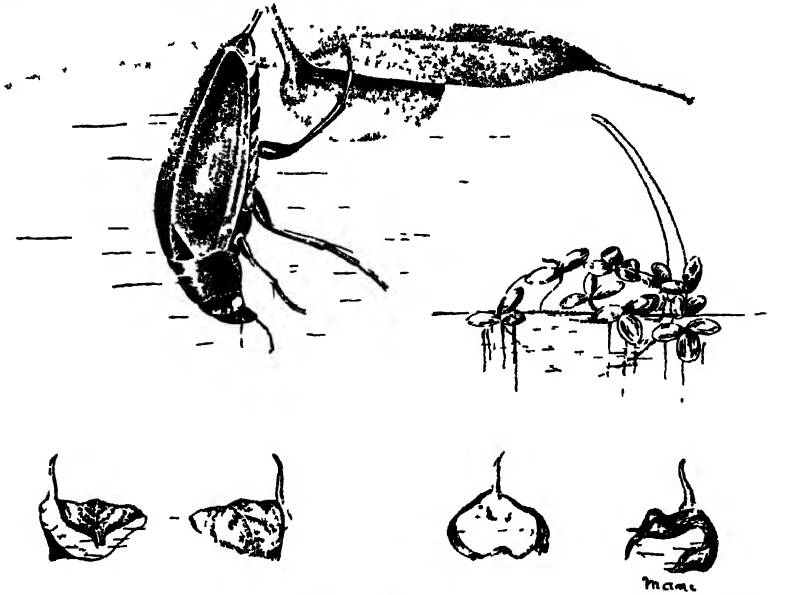

FIG. 4—The female aquatic beetle preparing its egg floats of silken threads (modified from Lengerken)

BROOD NESTS

Brood nests protect both the eggs and the larvae. A store of the food of the larva is also often placed in it by the mother. The nest becomes a nursery if the mother stays with her eggs and larvae to guard and feed them. Though the highest development is reached among the social insects, even among the other insects we find considerable skill in the selection of building material, nest site and actual construction of nest. Some insects do not themselves prepare the brood nest, but utilize existing facilities or even invade the brood nests of some other insect. Insects like the sexton beetle dig tunnels in sand on sea beaches. The female lives at the bottom of the tunnels and cuts out oval chambers all around for the eggs and uses the main gallery as shelter for the larvae that hatch.

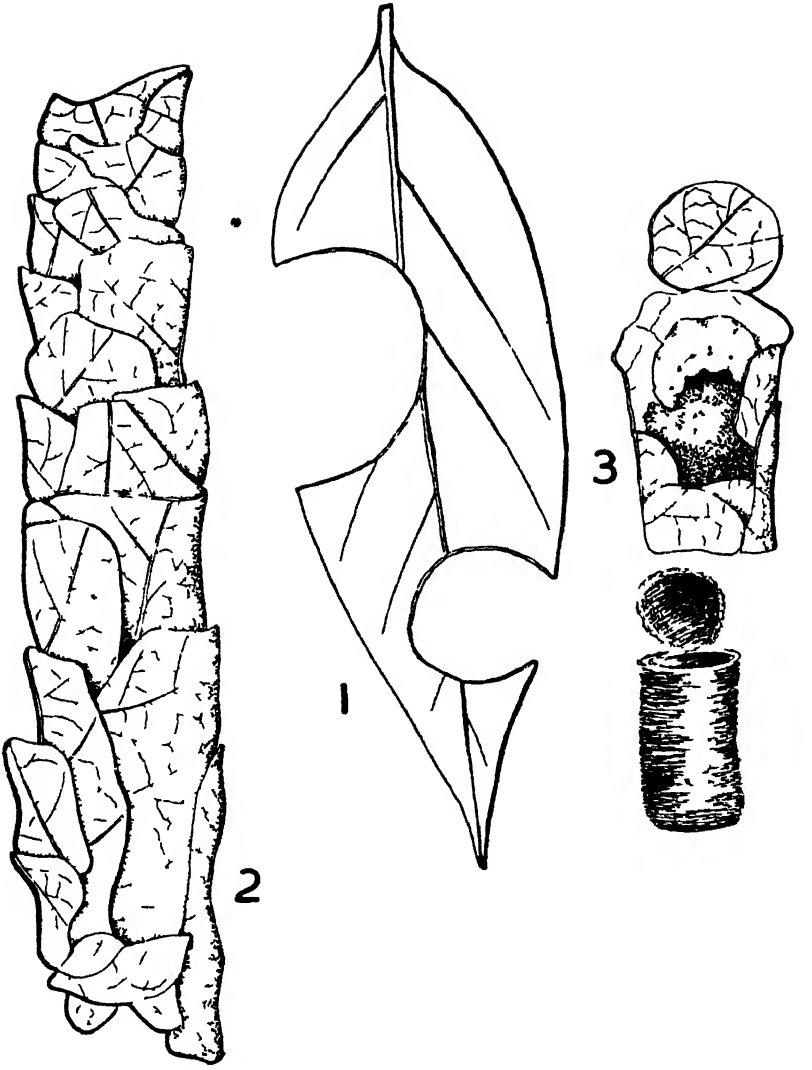

FIG 5—The brood nest of the leaf-cutting bee, constructed of pieces of leaf, cut expertly to size and constant shape 1. Leaf of the red-gram plant cut by the bee 2 A nest from outside. 3 One of the cells opened to show the lid of leaf, the bee larva on the mixture of honey and pollen stored by the mother.

The invasion of the brood nest of some other insect is a remarkable labour-saving method practised by many insects. Many predatory wasps seek the food of the larvae, perhaps a spider or a cricket, in its den and after paralyzing it by stinging, deposit their eggs on it. They then close the entrance to the den. The solitary wasp *Methoca* descends into the tunnel of the grubs of cicindelid beetles in sandy places, lands a paralyzing undercut on its neck, drags the doomed grub deeper into its own den, lays an egg on it and then fills the tunnel with sand and smoothens the surface. The Psammocharid wasps, whose larvae feed on spiders living in underground cavities, convert the spider's den into a brood nest. The female wasp coaxes the spider out of its den, overpowers it and stings it to paralysis. It then drags the spider back into the tunnel, lays it on its back and deposits an egg on its belly. On hatching, the Psammocharid larva feeds on the unresisting, but fresh and live spider, eventually consuming the whole of its body.

A number of insects construct their brood nests soon after pairing and often labour unceasingly till the nest is completed, adequate quantities of food stored up and the precious eggs safely concealed away.

The brood nest is established in all sorts of places, for example, in the ground, in old mud and brick walls, mud cliffs, rocks, tree trunks, etc. The bees *Osmia* establish their brood nests in telegraph poles, backs of old and undisturbed books, inside gun barrels, in the exhaust pipes of unused machinery and other out-of-the-way places. Some species of *Osmia* and another bee *Deuterogenia* appear to show a special partiality for old snail shells as brood nests. The preparation of the brood nests involves a series of acts like the selection of the site, clearing the ground, excavating, disposal of the resulting debris, transport of building material to the nest site often from great distances, building the cells to the correct size and shape, panelling the interior of the cells, tapestry and camouflaging the nest, etc. The nest-building technique is by no means rigidly fixed; most insects show remarkable powers of adaptability and are capable of modifying their habits and methods to suit unexpected local situations.

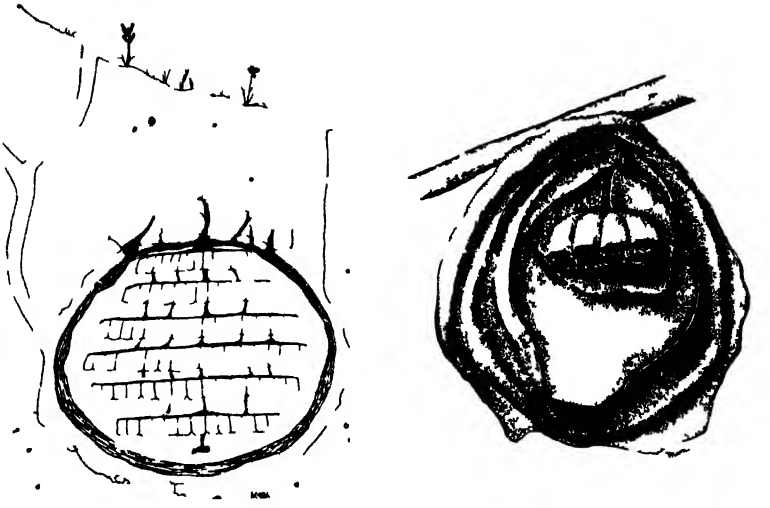

FIG 6- Paper nest of *Vespa* On the left is a diagrammatic section of the nest in an underground chamber The paper combs of hexagonal cells, arranged one below the other in tiers, are covered by a thick envelope of coarser paper pulp On the right is a new nest on a twig, with the first few cells made by the queen wasp, enclosed in four hoods

Nest-building by digging—Crickets, many beetles and other insects dig their brood nests At the time of breeding, the female never comes out of her underground quarters, but enlarges her old burrow and also adds side galleries that end in egg chambers The female of the dung-roller beetles *Geotrupes* and *Onthophagus* buries herself nearly thirty centimetres below the ground and digs with her front legs and thoracic shield A small mass of soil is first loosened and passed below the body to the middle legs, thence to the hind legs and finally behind the body When a sufficient lump of earth accumulates above the abdomen, the beetle stops digging, turns around and pushes with its head the loosened lump of mud to the surface of the ground After disposing of the debris she turns round and round, so as to give the tunnel a circular section She stamps and smoothens the walls and packs every-

thing in expertly and when the tunnel appears to be satisfactory, proceeds to lay eggs. You have to watch her at work to realize how serious and purposive she is, wasting no moment and taking no rest till her work is completed.

Nest by building—The nest-builders seek out various kinds of building materials and transport them to the building site that has already been carefully surveyed and selected. The building material may be available close at hand or it may have to be brought from a great distance. The mud-cell building wasps *Sceliphron*, *Rhynchium* and *Eumenes* bring their pellets of moist clay from over a distance of a kilometre. Sometimes the clay is first moistened with water brought in the mouth and then dug out with the help of the mandibles. The list of materials used in nest-building is inexhaustible: faecal pellets, green and dry leaves, sticks, plant fibres, thorns, pine needles, cotton and other plant hairs, mud, clay, pebbles, chalk, wax, gum, silken webbing, etc., are all used. For interior decoration and tapestry of the brood nests, cut pieces of leaves are widely employed. The leaf-cutting bees *Ceratina* and *Megachile*, for example, cut perfectly circular and uniformly large pieces of the leaves of rose, bauhinia, red-gram and other plants with astonishing rapidity. The pieces, often six or seven times larger than the bee itself, are carried during the flight to the nest, dangling expertly between the legs. Three or four pieces are first joined together into an outer envelope directly lining the interior of the nest cavity. To this is added two to five successive layers of pieces, with their margins overlapping and neatly tucked in. As soon as one cell is thus made ready, the insect fills it almost to the brim with a mixture of honey and pollen grains and lays an egg on top of it. The cell is then sealed off with pieces of leaf, often as many as eight, cut accurately to the diameter of the cell opening. A second cell is added above this lid, then a third and so on until about a dozen have been constructed.

The brood nest of the solitary wasp *Trypoxylon* is a partitioned clay tube, about 10 cm long and 1 cm wide. The female fetches a ball of mud, creeps into the growing tube and fixes the mud from inside to the outer rim, rolling the mud ball round at the same time.

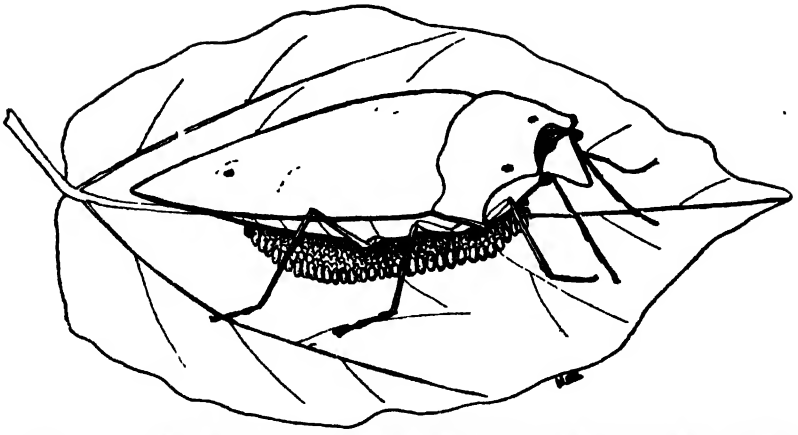

FIG. 7—The female pentatomid bug *Cantao ocellata* brooding over her eggs, deposited on a leaf.

The mud is applied uniformly all around and the tube grows longer and finally it is covered on the outside by irregular dabs of mud to conceal the true nature of the construction. *Eumenes* the mason wasp is perhaps the most familiar of our brood nesters in India. The female builds a complex of several pot-shaped cells of clay. She brings pellets of moist clay and spreads them out in a wide circle or curve on the selected site, to mark out the ground plan of the future cell. More and more pellets come and an arching wall rises up before your eyes until at last a beautiful pot with a circular mouth is made. She now hangs an egg by a fine thread from the roof of the pot and goes forth hunting for green caterpillars as food for the future larva. When the pot has been adequately provisioned, she tears off its rim, and with the mud closes it. Another pot is then begun. The potter wasp *Rhynchium* also makes a complex of about twenty oval pots arranged side by side with the tops of all the pots on one side and the whole complex treated with sticky gum-wash outside. The spider-hunting *Sceliphron* builds about a dozen elongated cells of mud placed side by side. While the *Rhynchium* female takes only three hours in making the pot, she spends three whole days in assiduously smearing on its surface a

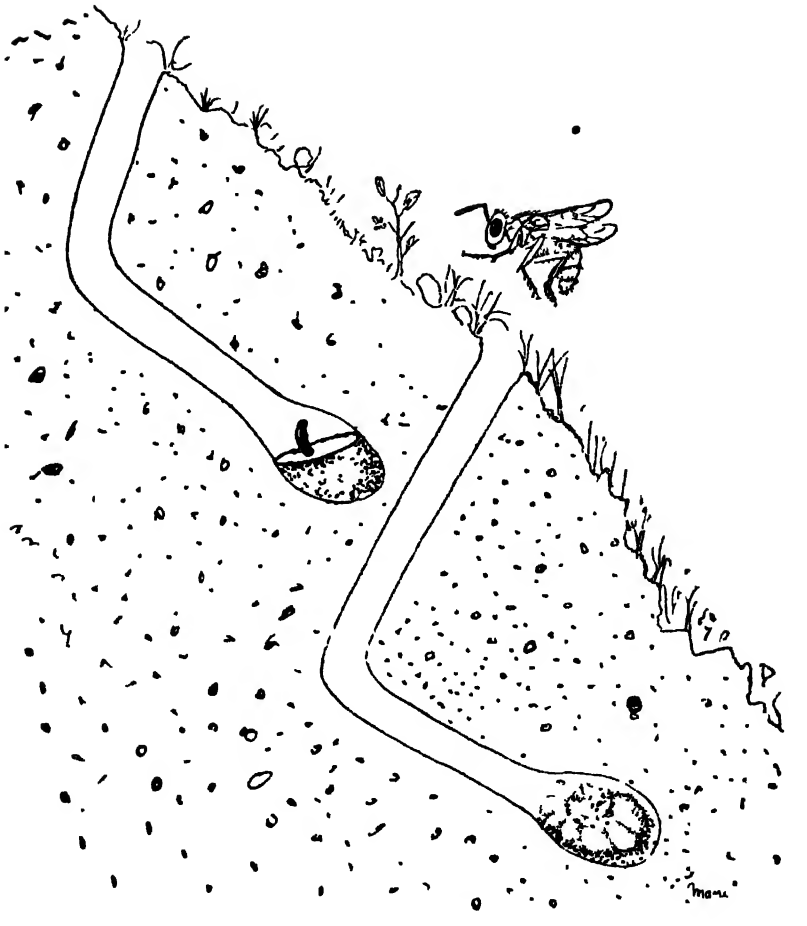

FIG. 8—Two brood cells of the ground-nesting solitary bee, dug underground in mud cliffs. At the bottom of the entrance shaft is a sharply bent gallery, leading to the large oval brood chamber at the bottom, filled with honey and larva.

thick layer of oozy and sticky gum in big globules. Each morning she goes forth among the trees, returns with globules of the oozing,

sticky and viscid mucilage, and smears it without a stop till darkness. The gathering and handling of the gum is a particularly tedious and messy job, but she never feels tired or soils herself. Not apparently satisfied with this, she sticks here and there a particularly large globule, inviting enough for an intruder to settle on it and get itself caught with no chance of escape. The gum is only on the outer surface and is never carried inside the pot. It takes a long time to dry and harden; and as it is wet and sticky for weeks and even months, it serves as a most effective death-trap to parasites that may dare to touch the pot with evil intentions.

How are the constant patterns achieved? How does the female solve so many architectural problems, without previous experience or training? Nest construction is attributed by scientists to inborn capacity, but there is undoubted evidence to show that a female measures heights with the length of her own body and diameters with her antennae. She works strictly according to a definite pattern, of which she has a clear idea right from the beginning. Before the mud cells are built up, she lays off the low ridges of mud to indicate the foundations of all the cells. She pushes her body fully extended into the cell or pot, in order to estimate the height of the construction. When the tips of the antennae touch the bottom and the tip of her abdomen touches the top of the rising wall, she knows that the correct size has been reached and at once stops further increase in height. The actual building is carried out in a fascinatingly regular and rhythmic manner, the female waving her body right and left like a pendulum, applying the mud pellet first to one side and then to the other. For some time she works from the outside, but when the wall has to curve into a dome, she steps inside to complete the job from there. She builds the nest exactly to the size of her own body, since her children are not likely to be larger than herself.

Provision of Food for the Young

In addition to taking precautionary measures for the safety of the eggs and the future larva, many insects also take the trouble of providing the food of a newly hatched young larva which is incapable

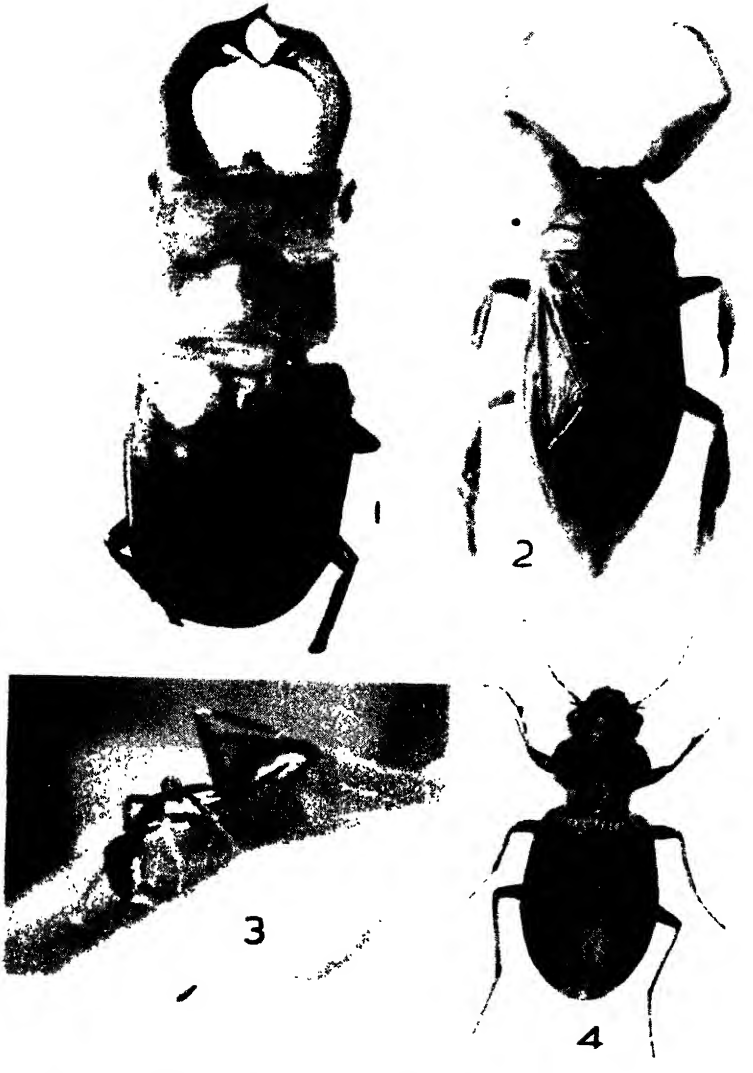

PLATE V. 1. Male staghorn beetle, with elongate mandibles. 2. The giant water-boatman bug *Belostoma*, with elongated add clawed fore legs which help in capturing and holding the prey: the bug sucks the blood of fish, frogs men and insects. Its other legs serve as paddles in swimming. 3. An ant worker busy searching for nectar on a flower. 4. A typical high-altitude Himalayan beetle *Bembidion* that is commonly found at elevations of about 4500 m above mean sea-level among snow and ice.

PLATE VI. Our common house cricket well known for its cheerful chirping at night in our kitchen. It is busy waving its antennae excitedly in response to the stage from them the male. Its stout hind legs enable it to jump expertly

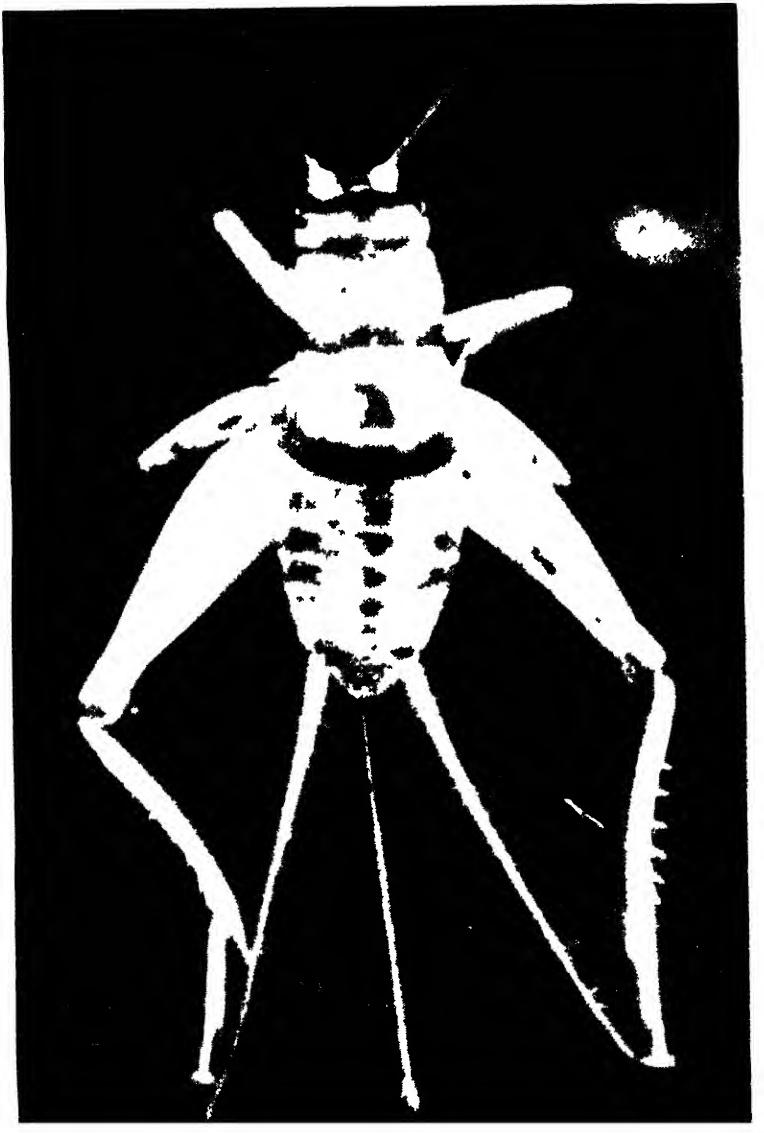

PLATE VIII [illegible]

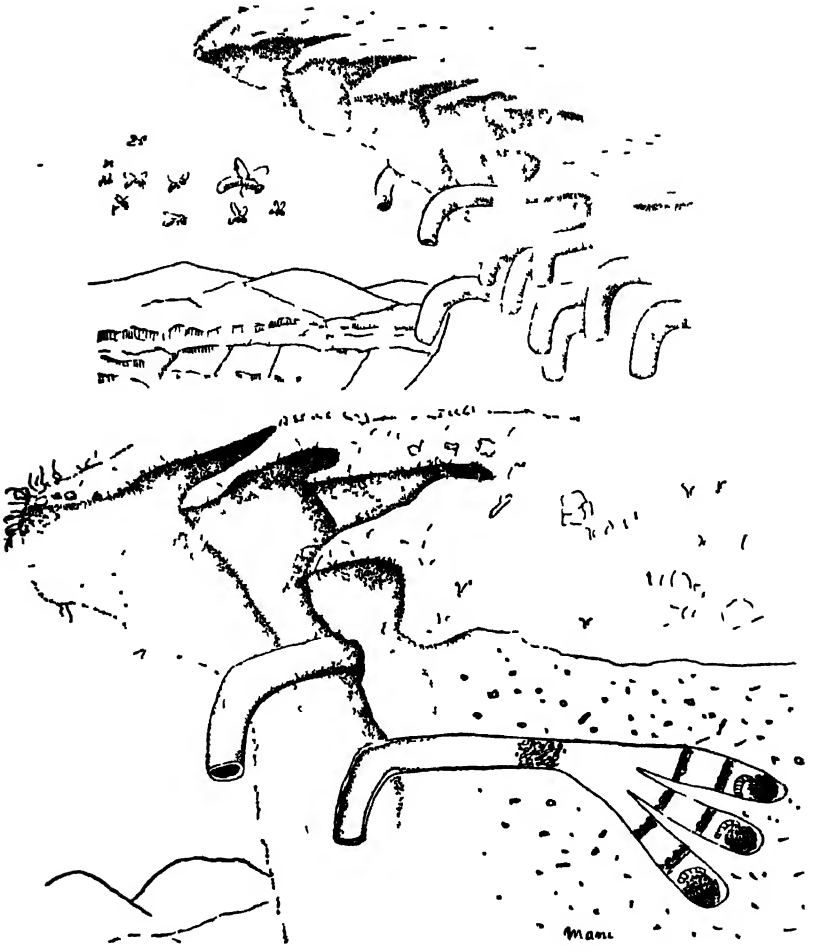

FIG. 9—The brood nests of some digger wasps are established in overhanging mud cliffs. The entrance is protected from rain and invasion by enemies by building a downwardly-curved chimney-shaped tube of mud that projects out prominently.

Brooding and Nursing

Not only among the social insects, but also in solitary species we know of instances of the mother continuing to live with her eggs and the newly hatched young ones, directly tending them, brooding over her eggs, cleaning them, protecting them from enemies and personally feeding the young larvae. Their family life stretches even beyond the emergence of the adult offspring. A brooding mother not only stays with her cluster of eggs, but also often carries them with her wherever she goes. Some of our common Pentatomid bugs deposit their eggs in a cluster on leaves and twigs and stand guard over them, carefully shielding them from the view of any intruder. *Cantao ocellatus* and *Tectacoris* are two common Indian bugs that brood over their eggs, completely hiding them from prying eyes. They leave only after the young ones have all hatched from the eggs and scattered for feeding. The solicitude of the mother extends even to the newly hatched larvae. The chrysomelid beetle *Phytodecta* lays about fifty eggs on leaves and stands guard over them. Soon the young larvae hatch and lead a semi-social life, feeding together and remaining with the mother all the time. The mother does not go far even for her own food. She does not distinguish between her own larvae and those of other females, but guards and looks after everyone that happens to come to her.

Many insect mothers go to the extent of always carrying their precious eggs with them. Even among the cockroaches this peculiar maternal solicitude is known. A remarkable South Indian aquatic cockroach is viviparous and gives birth to a number of young cockroaches. As soon as they are born, they promptly climb to their mother's back and remain protected under her wings. The young cockroaches leave the mother only after one or two moultings when they are able to fend for themselves. Our common mole-cricket *Gryliotalpa* prepares an underground nursery chamber in which she deposits her eggs. She broods over them, picks them up one by one now and then, licks them clean, feels them with her antennae and tenderly places them back on the ground in a close cluster. Her solicitude continues until all her eggs have hatched. The young

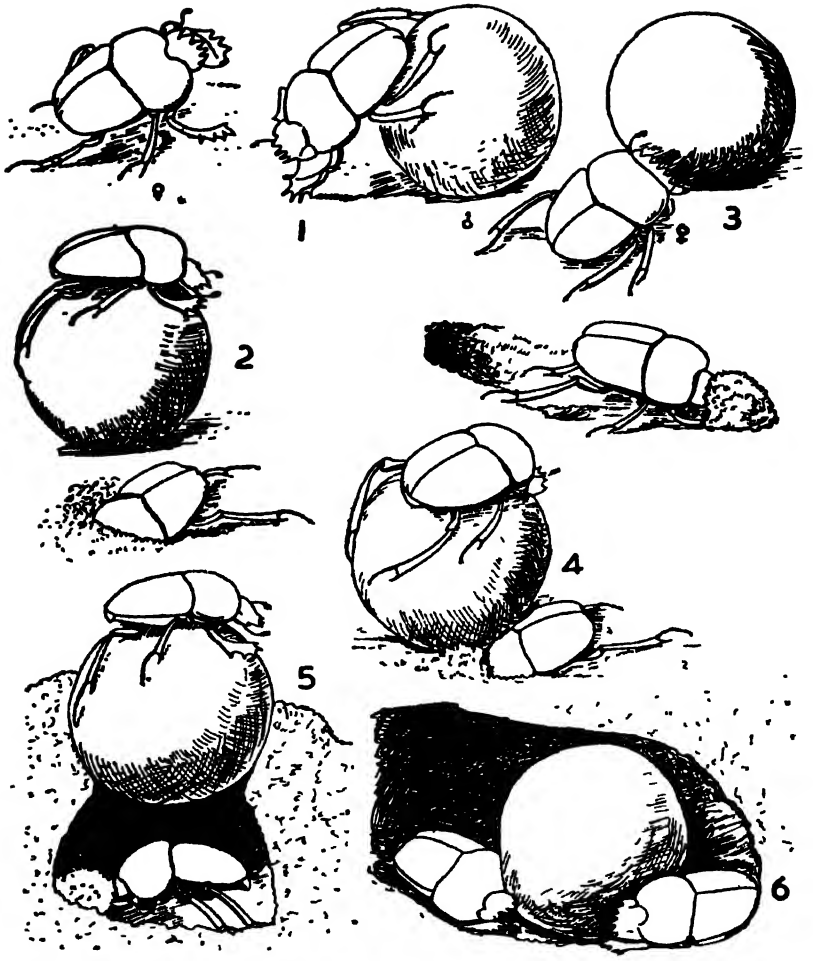

FIG. 11—The dung-roller sacred scarab beetle rolling a dung ball. 1. The father rolls the dung ball and the mother is following him. 2-3. On reaching the nest site, he starts digging with his head and she keeps guard over the dung-ball. 4. As the digging progresses, she moves the ball to the pit. 5. He is digging vigorously and she deftly manoeuvres the dung-ball to slip into the deepening tunnel. 6. The brood chamber is now ready and the father and mother have together successfully brought the dung-ball into it and are now happily busy arranging it in position prior to egg-laying.

remains in the burial chamber throughout the period of incubation of her eggs and the development of her larvae. After the eggs are laid she plugs the hole of the burial chamber. When the young ones hatch, she climbs over the decomposing cadaver and starts feeding on it. She does not, however, fill her stomach; she only eats to live for her young ones. Now the young ones leave the egg chambers, go to the main chamber and crowd round their mother. An extraordinary thing then happens: a young larva creeps below its mother and waits with its head between her mandibles now widely opened. A glistening drop of brown liquid of the predigested meat extract is regurgitated by the mother into the eager mouth of the larva. The mother swallows more and more meat, merely to feed her growing children. She even makes a faint scraping noise with her legs as a signal to the children that feeding time is on.

The Father Lends a Hand

It is not always that parental care devolves exclusively on the mother; very often the father also lends a hand by baby-sitting, brooding over the eggs or co-operating with the mother in other ways. Sometimes he does everything single-handed, without assistance or encouragement from his wife; or he may play an unwilling and secondary role and is promptly thrown out by his wife after his work is over. His lot is at best most unenviable. He performs his duties alone unwillingly and is a "grumbling" father. He is in effect forced by his spouse to look after the young ones, while she herself goes out pleasure-seeking or dating with other males. The poor fellow rarely, if ever, rebels against his wife. The giant water-boatman *Belostoma* a bug which is extremely common in rice fields, ponds and lakes all over our country and comes to light in large numbers during the monsoon rains, provides the most interesting example of the grumbling father. He has to carry the entire brood of his wife's eggs on his back until all the young hatch and jump into the water. The female bug forcibly seizes the male and converts him into an animated incubator-cum-perambulator for her eggs. After securing him firmly under her legs, she climbs on to his back. He protests vehemently and struggles frantically to break loose, but

in the end has to submit to her superior strength. Then he hangs unresisting, with his back up and his legs limp, reconciled to his fate and looking as unhappy as a drenched cat. The female now calmly proceeds to lay her eggs on his back and glues them securely by means of a quick-hardening and water-proof cement. Each egg is set nicely on its side and in a row. When she has thus covered him with about fifty eggs, she releases him. The egg-bearing male naturally dislikes this forced servitude. To do him justice, he tries vigorously to rid himself of the unwanted burden imposed on him by his domineering wife. From time to time, he passes his legs over his back in a vain effort to rub the eggs off. Rarely he succeeds in dislodging some of them and then takes revenge by sucking them dry. He seems, however, to be aware of the fact that what cannot be cured has to be endured and so he usually carries the eggs placidly on his back, for fifteen days or so, by which time the young bugs hatch, restoring him to his freedom and dignity. By carrying the eggs on his back, he plays a vital role without realizing it, thereby he keeps them properly aerated and wet as he rises to the surface of the water to breathe. The eggs will not hatch if they are not carried by the father; it has been experimentally shown that by removing the eggs to a glass trough filled with water, they perish very soon. The eggs must be in water and yet be exposed to the air every now and then. What better way could have been thought of by the mother than to compel her worthless husband do this job? He does it exceedingly efficiently too.

The grumbling *Belostoma* father is an exception, because in most insects the father enjoys lending a hand in the performance of parental duties. Though he often plays a relatively minor role, he is a willing collaborator of the mother. He helps his wife in her work by choice and not out of compulsion; he runs about doing all sorts of sundry jobs, excavating the brood nest, removing the debris when the wife is digging, conveying the larval food, arranging it in the larder, guarding the entrance to the brood nest and even sometimes personally feeding the young. His willing co-operation saves the mother a great deal of energy and time. The female of the dung-roller beetle *Onthophagus* takes about five to six hours in completing

and provisioning the brood nest alone, but with the assistance of her husband, she does it in about three hours. This enables her to lay many more eggs. Although the mother is capable of doing everything herself, the male is anxious to contribute his mite. Instances are known where he fights for the privilege of serving the brood. Very often there is a clear division of labour between the mother and the father—he works out-of-doors as the bread-winner and brings the provisions; she works indoors in the nursery and is the bread-maker who prepares food for the larvae. She digs the nursery chamber and he guards it. They live and labour in monogamous bliss.

Foster Parents

We have so far discussed the solicitude of insects for their offspring. Many insects do not, however, take any trouble to protect their eggs or larvae. They also do not build brood nests or gather food for the future young ones, but take advantage of the parental solicitude of others to satisfy their own needs. The female contrives to smuggle her eggs stealthily into the well-provisioned brood nest of another insect. On hatching, her larvae feed on the food materials gathered and stored up by the owner of the brood nest for her own young ones.

In a number of cases, the original brood-nest building female acts as a foster mother and tends both her larvae and the ones smuggled in. The robber-bee *Coelioxys* smuggles her eggs into the brood nest of the leaf-cutting bee *Megachile*. Another bee *Stelis* does the same thing in the nest of the bee *Anthidium*. The female of the golden cuckoo wasps of the family Chrysididae hides behind some bush or stone at a little distance from the entrance to the brood nest of another insect, and waits motionless but extremely alert. It leaves the spot when the other insect goes out and quickly drops its eggs into the ready-made and already provisioned nest.

Parental Care, the All-driving Force

We are so accustomed to think of parental care as an exclusive human trait that we do not generally realize that solicitude for the

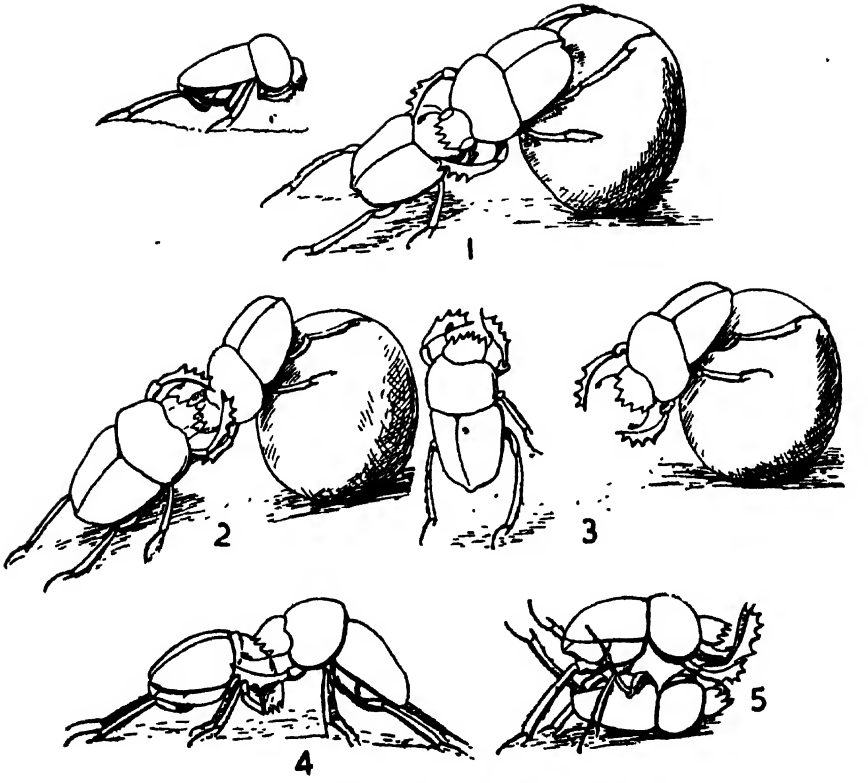

FIG. 12—The male dung-roller beetle fights for the privilege of rolling the dung-ball to the brood nest. Bitter fights result and the issue is settled by a third male which rolls away the ball, leaving the two to fight till they become exhausted and disappointed.

young is the driving force behind all insect activity. We have, however, seen the way in which insects look after their young. Not only do they ensure the conditions necessary for the proper incubation of their eggs, but also actively protect them from adverse climatic influences and guard them from enemies. How wonderfully "clever" are some of their methods of camouflaging

their eggs! What surprising skill and resourcefulness do they show in the construction of their brood nests! Think of the numerous ways in which they make provision for the food of their future offspring. Watch a wasp labouring unceasingly to build and provision her brood nest and die almost in harness. Yet she never lives to see her child for which she has dedicated her life. A number of insects directly attend to the needs of their eggs and larvae, shelter them from the scorching heat of the sun or from driving rain, shield them with their own body and guard them from their enemies. Even the father, generally irresponsible, occasionally looks after the nursery. The devotion of the elder sisters to the young ones among the social insects is an extension of maternal solicitude and evokes our admiration. From the time an insect becomes sexually mature, all its activities appear to be directed to one end, viz., the welfare of its future offspring. The sum total of insect behaviour is thus maternal. *The female insect is essentially a mother, not a wife.* Herein perhaps lies the clue to the eternal enigma, woman; it is true of the human being too. No wonder our ancient literature respects woman as a mother and deifies motherhood.

Maternal solicitude among insects is associated with habits, social life and intelligence. An orthodox biologist will, however, tell us that their activities do not show any mind comparable to that of man. Even ants are unreasoning and are slaves of complex "instincts", which, however admirable, are inferior to "intelligence". One eminent entomologist of Europe, who has written much on Indian insects, summarizes the common anthropocentric attitude of scientists succinctly when he remarks "a dog has more reasoning power and higher order of mentality than the highest insect; the absolute stupidity of the ant but the wonderful nature of its instinct is a curious contrast."

Is the insect then moved only by instinct? Is there no gleam of intelligence in insect behaviour? Does not parental care among them acquire an emotional tone at some level? Is the insect merely an automaton, bound inexorably to the tyranny of routine, lacking in sentiment, as Fabre, the famous French naturalist, would have us believe? There is unfortunately much misunderstanding in this

respect. Fabre, who spent a lifetime observing insects and conducted some orthodox experiments, drained away all the honey stored up by the mason-bee *Chalcodoma* in its tube. He found that the bee went on with the routine of egg-laying and closing the tube utterly unmindful of the disappearance of the larval food. From this observation he concluded that the bee is ruled so completely by instinct that she does not even estimate the amount of the store of food she has placed in her brood nest. She accumulates it as long as the "gathering instinct" is within her. Was he right ? Let us see. Some years ago we found a mud wasp *Eumenes* building her nest in our room. We removed the paralyzed caterpillars from her brood nest as fast as she brought them in. She took no notice of it at first, and continued to bring in more caterpillars and push them into the empty cell. By nightfall we had robbed her of five caterpillars, a number more than sufficient for at least two nests. Next morning she brought more caterpillars, but again we removed them. Now she began to show evident signs of worry. She made calls to her cells at frequent intervals, without bringing caterpillars, and merely for inspection. We now left her in peace and she brought two caterpillars which alone were needed to fill her cell, and then closed it. If instinct alone was the guide, the wasp would have brought only one or two caterpillars which are normally su cient to fill her cell. Having done that, her instinct should have been satisfied and she should have then closed the cell, even though it remained empty. She was, however, not satisfied, because she knew that her cell was empty and she persisted in bringing more and more caterpillars.

In another experiment, Fabre barred the exit of a young mason-bee from a reed cavity by a double barrier, an inner one of clay and an outer one of paper. The bee bored through the mud barrier, but not the paper. He concluded that the bee's instinct is to cut through its way once and having done so, its instinct was satisfied; it did not repeat the act, because the routine was over and it was helpless in front of the paper barrier. We found, however, that the fault lay with the observer and not with the bee. We transferred the larva of a mason-wasp to a glass tube, the mouth of which was blocked by three mud barriers, each one twice the thickness of her

natural mud cell. From Fabre's experience one would expect the young wasp to cut through only the first partition, and because her instinct was satisfied she would not be able to break through the second and the third barriers and she would die in a few days. Our surprise was great when one morning we found that the wasp had broken down all the three barriers and had made its escape. The bee or the wasp is normally accustomed to mud partitions and paper is something wholly outside their experience. How can we find fault with them if they fail to recognize it ? If an inhabitant of a far-away planet enclosed us in a material that is totally unknown on the earth, would we recognize it ? The trouble with most scientists is that they plan their experiments in such a way that insects are placed under conditions which are totally outside their normal experience. We must not forget that no animal, including man, is likely to show more intelligence than the conditions of its life ordinarily demand. Want of appreciation of this very important fact often leads to much misapprehension.

Though it is not unusual for the digger wasp to construct a brood nest herself and bring into it the paralyzed prey, we have already seen that she drags the paralysed prey back to its own burrow from which it was driven out only a few minutes earlier. The reason for this peculiar behaviour is not difficult to seek. A cricket, which is often the prey, is a monster when compared with the digger wasp and cannot, therefore, be easily transported to a specially prepared nest. Again the wasp, though an expert digger, cannot excavate a tunnel wider than her own dimension. The victim being far bigger, the wasp seems to know that she has to bring it back to its own burrow. Now we threw a number of crickets before a female digger wasp which we had once seen hunting for them. She recognized the prey offered by us, showed great excitement, but stubbornly refrained from snatching or stinging any of them. It looked rather stupid of the wasp not to have accepted our offer of crickets and saved herself the trouble of hunting for them. But supposing she had done so, she would not have gained anything, The paralyzed cricket would gradually recover from the anaesthesia she had administered but there was no place to drag it into. The

temporary nature of the sting avoids waste of time in searching for a suitable hole to push the victim down into. No wonder that the wasp refused to accept our offer, however tempting it may have been. It may also seem silly on the part of the digger wasp that having found the cricket at the bottom of the burrow, it does not sting it then and there, but first drives it out and then runs the risk of the chase and possible escape of the prey. Within the narrow tunnel, the wasp does not dare to come to grips with the cricket, because of its wholesome fear of its terrible vice-like jaws. She must at all costs avoid a frontal attack and jump on the victim from behind. This is impossible inside the tunnel and the wasp has of necessity to drive it out first. It is perfectly aware of the situation and proceeds about the job in a most purposeful way. The surprising fact is that while the cricket also seems to know the evil intentions of the wasp, it does not run out of its tunnel, until forced out.

Some of the spider-hunting *Pompilus* wasps exhibit unmistakable signs of intelligent appreciation of the situation with which they are faced. Certain ground-nesting spiders lurk at the bottom of a Y-shaped tunnel which has two separate entrances closed by silken doors at some distance from each other and leading down to the living chamber at the bottom. Here is a most interesting situation. If the wasp enters through one of the doors, the spider is likely to escape by the other. The wasp has three courses open. Firstly, it can break one door and when the spider comes out for repair catch it. Secondly, the wasp can insert the tip of its abdomen into one door and then abruptly draw it out to frighten the spider, and at the same time keep an eye on the other door for the spider's possible bid for escape. Thirdly, it can rap first one door and then the other until the spider becomes confused and runs out. We found the interesting point that the wasp tries all the three methods, depending on local conditions.

We have ample evidence to show that though insects have very powerful instincts, they are not inexorably bound down by them and are by no means slaves of routine. They can recognize new situations and alter their behaviour accordingly. While largely instinctive, their parental behaviour is guided, at least in some

cases, by intelligent appreciation of changed circumstances; at least in cases where the parents continue to remain with their young ones, we must credit them with genuine parental feelings. We must not overemphasize the instinctive basis of parental care in insects, because even in higher animals, including man, maternal care is to a great extent instinctive. It is our common experience that women are governed largely by instincts and are thus right almost every time!

CHAPTER IV

INSECT LIFE IN AN INDIAN GARDEN

THOUGH insects are quite common even in our homes, they are essentially outdoor creatures that love open air, bright sunshine and lush green vegetation. In the garden, meadow or jungle they have their traditional ancestral homes, where their lives and habits have not been affected by association with human beings. While only a very small minority of our insects take advantage of the comparative ease and luxury of life inside human dwellings, the great majority of them have preferred to stick to their natural habitat. Although man is trying his best to drive them out of their natural homes, they still successfully hold on to their own. In our country, out-of-door insect life is peculiarly Indian, rich, diversified, colourful, bizarre, ancient and modern and in perfect harmony with Nature. Grasshoppers, crickets and katytids large and small, beautiful and grotesque, jump in the lush green grass and low plants; stinking bugs move leisurely among the bushes; cicadas sing on trees; shiny beetles rush about; colourful and showy butterflies flutter from flower to flower; busy bees hum sweetly. An occasional wasp appears as if from nowhere whirring its wings to swoop down on its unsuspecting victim. Flies and gnats swarm in their millions and dance gracefully in the warm evening air, the lovely moths fly silently like angels among the sweet-scented white flowers; and myriads of twinkling specks of fireflies and glow-worms add enchantment to our warm moonless nights. Let us go out and meet these enchanted children of our land.

THE GRASSHOPPERS

The grasshopper, most appropriately named, is a jumping insect which does not believe in mere walking or crawling or running. Long and high jumps are the delights of a grasshopper, which in an emergency can of course fly. Grasshoppers are happy and at home among green grass and low green vegetation.

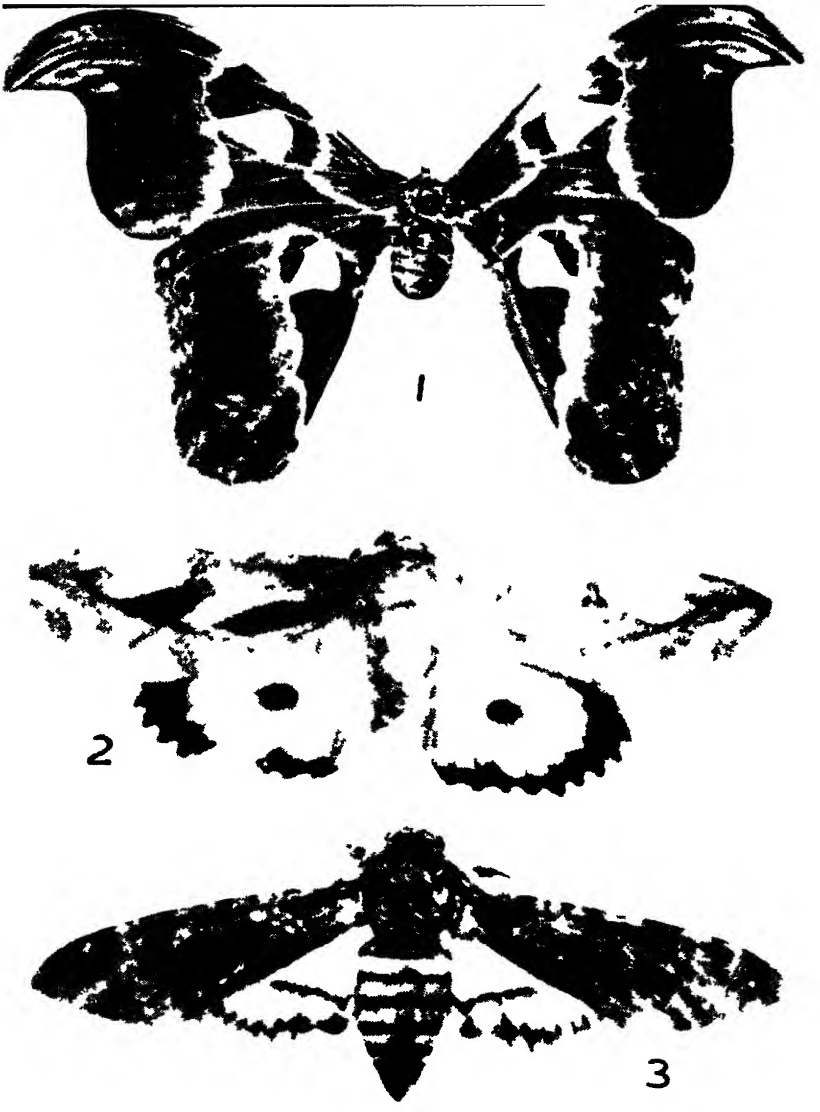

PLATE IX Some of our common moths 1 The atlas moth *Attacus atlas* the largest of our moths it lives in dense forest 2 A fruit sucking moth, which punctures the rind of oranges lemons and mango and sucks the sweet juice at night the caterpillar feeds on leaves of various wild plants 3 The common deaths head moth *Acherontia styx* a powerful flier it is so called because of the fanciful skull-cross bone marking on its back

Grasshoppers and their cousins the crickets are placed in the order Orthoptera, in which the front wings are narrow and leathery and the hind wings are membranous, large and folded like a fan when not in use. Their jaws are strong and bear sharply pointed and massive teeth for cutting and grinding rough and solid food like leaves and grass blades. Their hind legs are much longer and stouter than the other legs; with these the insect jumps with lightning-like suddenness. Nearly all grasshoppers are coloured bright green, yellow, orange, red, brown or grey and often blend so well with the background of foliage on which they live that you will fail to spot them even at close quarters until they jump. They are incurable gluttons, and often completely denude whole bushes in a very short time. During monsoon rains they are most abundant. Unfortunately they have numerous enemies, in particular the common mynah of our garden, *Acridotheres tristis* (to give it its dignified scientific name), which seems to think that God has created the grasshoppers expressly for its dinner-table. This bird will snap up grasshoppers by the dozen from a bush in which you will see none.

Our grasshoppers are of two kinds: the short-horned grasshoppers or the acridids and the long-horned grasshoppers or the tettigonids (also called katytids). The acridids have short antennae and short ovipositor at the tip of their abdomen for egg-laying. For hearing they have a tympanum or a peculiar ear-drum below the wings, at the base of their abdomen. By stridulating or rubbing the rough surface of the wing against the leg, they produce a peculiar sound in the same way as the bow drawn on a violin string. They lay a cluster of eggs in small pockets underground. The tettigonids have long, threadlike antennae, which are often much longer than the body and a long sword-shaped ovipositor. Their ear-drum is placed on the shin or the tibia of their front leg. The tettigonids usually thrust their eggs under the bark of plants.

The Short-horned Grasshoppers

Our short-horned grasshoppers deposit their eggs in a compact cluster in the soil, imbedded in a gummy matter that hardens

quickly. Each cluster may contain from fifty to over one hundred eggs. The development of the eggs under the ground is rather slow and may take the whole winter or the dry summer season. The egg stage lasts from October to June in many species, and from June to July in others. The slowing down of the development during winter is called hibernation and the similar retardation during hot summer is called aestivation.

On hatching from the eggs, the young grasshoppers generally resemble the adults, except that they lack wings. They are usually coloured yellow or green, differently from the adult. They feed voraciously, grow rapidly and moult their skin five to seven times. The wings appear as ever-increasing lobes from the third moulting or sometimes from the fourth. The adult grasshoppers turn brown or red. Many have a single generation in a year, but others have two of unequal duration. Rarely, some kinds of grasshoppers pass through several generations in a year.

There are perhaps over one thousand species of short-horned grasshoppers in India. Some of the more common and bizarre ones may be mentioned here. *Acrida turrita* is a slim creature of variable colour, ranging from bright green to dry-grass green and with flattened antennae. *Epacromia dorsalis* is a widely distributed grasshopper which is strongly attracted to electric lights during the rains. *Aedaleus marmoralis* with a brilliant orange and black colour is also widely distributed in our country. *Aularches miliaris*, found in low hilly areas, is coloured dark green to black and spotted yellow or red. The painted grasshopper *Poecilocerus pictus* is perhaps the most beautiful. It is found on the calotropis plant almost throughout India. The yellow-coloured young ones have bright black and red spots and as the moultings take place, the colour turns blue and yellow. *Atractomorpha crenulata* also occurs throughout India; the female is green, but the male which is smaller than the female is brown. Though it feeds on a great variety of wild plants, it seems to prefer eating tobacco leaves if it can. An interesting grasshopper is the so-called Bombay locust *Cyrtacanthacris succincta* which often flies in great swarms of reddish clouds over grass and paddy fields in the Deccan. We

find in our fields two other common green-coloured and smaller grasshoppers *Hieroglyphus banian* and *Oxya velox*, causing damage to various crops, particularly paddy. Mention must also be made of the rather grotesque giant grasshopper *Teratodus monticollis*, common in South and Western India. This is a green or dry-grass-coloured monster, with an enormous rooflike hood projecting backward from the head over the rest of the body.

The Long-horned Grasshoppers

Our long-horned grasshoppers are usually large and green, often leaf-like, sometimes brown and bark-like. Unlike their short-horned cousins, they are nocturnal creatures. Some are vegetarians, but others predacious on other insects. They are found in India in abundance, mostly during the monsoon rains when they are readily attracted by light at night. They produce a shrill and harsh sound. *Mecopoda* and *Holochlora* are two of our common long-horned grasshoppers; the former has a curious dark brown dead-leaf colour and occurs on trees. *Sarthrophyllia* is a flattened, bark-like creature which rests motionless on tree trunks during the day time. *Conocephalus* is a green, attenuated long insect, found commonly in the grass, the male of which produces a sustained shrill noise, deafening to the ear.

THE CRICKETS

The crickets or Gryllids are great chirpers and expert burrowers, though some live exclusively on the surface of the ground. Most burrowing crickets are vegetarians, feeding on the roots of plants, but some also come out at night to feed on leaves and buds.

The crickets are rightly famed for the loud and sustained shrill note produced by rapidly rubbing a rough area of the right wing over one of the left. The note is sometimes so shrill that it is beyond the range of sound perception of the human ear. The word cricket is a corruption of crickle, an imitation of their crickling noise.

Brachytrepes achatinus is a large brown cricket common in many parts of North India; it comes above the ground in good number

at night when heavy monsoon rains flood them out of their burrows. The male usually comes out at dusk and starts singing in an ear-splitting note. Perhaps the most familiar of our field crickets is the mole-cricket *Gryllotalpa*, which has stout front legs modified as shovels and hoes for digging. They are large, brown creatures living in underground chambers, in which they raise their young ones. They often enter our houses attracted by light. In South India they are popularly called *pillai poochi* under the mistaken notion that they induce pregnancy in a woman if one is swallowed with some jaggery.

THE BUGS

Bugs, unlike grasshoppers and crickets, take only liquid food. They have no teeth to bite and chew solid food, but instead have a jointed beak, enclosing four sharply pointed needle-like long stylets. The bugs pierce the bark of plants or the skins of animals and suck sap or blood. With the exception of some highly specialized plant bugs and isolated animal parasitic bugs, the great majority of our bugs live in the open and occur mostly on low-growing plants; some are even able to climb trees. Many are brilliantly coloured red, orange, yellow, green, black, metallic blue, or coppery-red; they have exquisite spots and bands and are endowed with great beauty. When disturbed, they emit a stinking odour that strongly reminds us of the crushed bedbug. This stink is due to a highly volatile oily secretion discharged from certain glands. Many secrete a waxy coating which protects their body from excessive loss of water in dry weather. Some bugs, like the lac insect, secrete copious resinous material. Like most of the grasshoppers, the bugs are particularly abundant in India during monsoon rains and for a brief spell afterwards. There are two kinds of bugs, viz., the so-called true bugs or Heteroptera and the cicadas, aphids, mealybugs, etc., or the Homoptera.

HETEROPTERA

In the true bugs, the fore wings are leathery basally, but the tip is always thin, delicate and membranous like the hind wings. The

wings develop gradually and become evident as stumps two or three moults before attaining adult stage. Some free-living and parasitic bugs have totally lost their wings. Though most bugs are usually slow-moving, many can run vigorously and others jump like a grasshopper. A number of them are aquatic or semi-aquatic; they walk on the surface of water without floundering or they dive and swim with the help of their legs. One or two species have even invaded the sea. All bugs love warmth and humidity.

The most common and perhaps the most striking of our bugs like *Chrysocoris*, *Cantao*, *Scutellera* and *Coptosoma* are hard-bodied and look very much like beetles and coloured bright orange, green, brown or black, or metallic-green, blue or coppery-red and usually beautifully spotted. A large shield extends over the whole of their back and often conceals the wings, which may even be atrophied. Most of these bugs are about a centimetre long. Their general habits and life-histories are more or less similar. The eggs are usually deposited in small clusters on plants. In a few days tiny young ones called nymphs hatch from the eggs. The nymphs are generally very active and look like adults, but are smaller and differently coloured and naturally lack wings. They suck plant juices, moult their skins about five times, gradually develop wings and become sexually mature adults. The nymphal stage is usually of short duration, and the adults live relatively longer. While the adult bugs expose themselves on plants, the nymphs usually remain concealed in the soil or under leaves.

Chrysocoris stolli is a most beautiful bug, large and brilliant metallic-green and found commonly on jatropha plants in South India. When disturbed, it promptly drops to the ground, and disappears among the fallen leaves and sticks. *Nezara viridula* is a slightly smaller bug green or yellow coloured and found on the leaves of various plants, including many cultivated ones. *Tessaratoma javanica* is a conspicuous brown bug, about 3 cm long and producing a shrill noise when disturbed. The coreid bugs have curiously shaped appendages and leaf-like expansions on legs. *Leptocorixa* is the notorious ricebug which causes severe damage to the paddy crop in some parts of the country; however, it prefers to

feed on wild grasses, which are its primary food plants. Its taste for the rice plant is an acquired one. The Lygaeid bugs are generally small, but vividly coloured, with long legs for running. *Spilostethus*, occurring commonly on calotropis plants, may also be found on cotton; it is a red-coloured bug, with black markings. Unrelated to it but very similar to and often mistaken for it is the pyrocorid bug *Dysdercus cingulatus*, also popularly called the red cotton-stainer bug.

HOMOPTERA

The Homoptera differ from true bugs in that both their pairs of wings are similar. They are plant feeders, some having degenerated into permanent parasites on various plants, and lost their wings and power of locomotion. They are capable of moving about for a brief time after hatching from the eggs, but soon settle down on some suitable place on a plant. There they drive their long piercing stylets into the plant tissues and stay put for the rest of their lives. They suck large quantities of sap and concentrate the liquids absorbed by secreting a watery honey-dew. The plant suffers injury and withers away prematurely. To the Homoptera belong such well-known insects as the lac-insect, the aphids, cow-bugs, cicadas, mealy-bugs, scale-insects, etc.

While the Heteroptera love warmth, the Homoptera are abundant in the cooler areas. Many of them cause damage to crops, vegetables and fruits, not only by draining away the essential sap, but also by injecting with their saliva virus and other pathogenic agents of plant diseases. The aphids are among the most numerous and common homopterous bugs. They are minute, delicate, winged or wingless creatures, occurring gregariously on the tender parts of plants like grass, beans, mustard, radish, cotton, rose, calotropis, etc. The aphids are usually attended by crowds of ants, which regularly milk them for the sweet honeydew they secrete. The ants care for the aphids, protect them from their enemies and transport them to their feeding-grounds and in return for all these troubles enjoy the honeydew, which they obtain by stroking the aphids with their antennae. They normally reproduce

as virgins, because there have been no males among them through generations. The mother aphid does not lay eggs but is viviparous and gives birth to young aphids. After many parthenogenetic generations of viviparous virgins, both males and females may appear in great numbers. Some of these winged males and females migrate to different food plants, where they mate and the female may then lay a single egg. A wingless female hatches from this egg and starts reproducing parthenogenetically and viviparously. An aphid often starts reproducing within three or four days after birth. In the plains the aphids reproduce nearly wholly parthenogenetically, but in temperate areas and on the Himalaya both males and females can be found. The aphids have numerous enemies like birds, ladybird beetles, flies, hymenopterous parasites, etc.

Cicadas are large insects which are inhabitants of forests. They are remarkable for their prolonged infancy. The young cicada nymphs dig in the soil and suck the roots of trees and develop very slowly through thirteen, seventeen or more years, but their adult life is only a few weeks long They are dependent on trees for food—the adult cicada sucks sap. They are coloured and marked like the bark of trees on which they live. They are famous as insect musicians and are known by their shrill and sustained whistle. It is only the male that sings; the female can hear but cannot answer, as she is incapable of producing sound. No wonder then that the poet envied them when he sang

"Happy the cicada's lives
They have voiceless wives."

The sound is produced by a rapid vibration of a tympanum or drum membrane, stretched tightly across the opening of a hollow cavity and is greatly amplified by a high fidelity volume-control sound-box, filled with resonating air. Different species of cicadas produce different sounds ranging from rasping to whistling, and since there are hundreds and thousands of them singing at the same time on trees in a forest, it is impossible to say precisely from

where the sound is coming. The effect is always deafening. Cicadas are rather rare in the plains, but abundant on the hills and on the Himalaya. Our commonest cicada is *Platypleura*. Cicadas may not be seen in a place for many years; then they appear suddenly in great crowds, only to disappear totally for many years. Literally they go underground.

THE BEETLES

The beetles are hard-bodied insects with the front wings modified into horny shells called elytra. The elytra do not function as wings, but serve rather as protective covers for the delicate and membranous hind wings, which are folded and tucked under the elytra when not in use. When the beetle is air-borne, the elytra are of course opened out too, but do not materially assist either in producing the lift or the forward motion of the body. With few exceptions, beetles bite and chew solid food, which may include leaves, buds, flowers, fruits, nuts, seeds, stems and other parts of living plants or wood, decaying and dead organic matter or also living animals.

The beetles range in size from 0.25 mm to over 15 cm and are brown, black, red or yellow or bright and shiny metallic-green, blue or coppery-red and very often beautifully spotted and marked. Most beetles are swift runners on the ground, others dig underground, but many live in bushes and trees. Some are expert divers and swimmers. Their development is a complete metamorphosis, the larvae belonging to many types and having diverse habits.

The beetles are placed in the Order Coleoptera, which is the most dominant group of insects on the earth at present, because they far outnumber both as individuals and as species all other groups of insects. They are abundant everywhere, from the tropics to the frozen arctic, in forests as well as deserts, in the sea-shore and the shadows of the Himalayan peaks, in the open as well as inside caves, in ponds, lakes, streams and in hot and chemical springs.

Many species of beetles are of economic importance, because they

destroy standing crops in the field, spoil stored grains and various other raw and manufactured goods. Some yield valuable medicines like cantharidine, and others are used in art and in the manufacture of jewellery. A few have been employed in our country and elsewhere with remarkable success in controlling insects injurious to fruit trees.

The Order Coleoptera is divided into complex suborders, superfamilies and families, which are too numerous to be listed here. Some of the more common and peculiar beetles are the Cicindelids or the tiger-beetles, Carabids or the ground-beetles, Scarabaeids, ladybird beetles, blister beetles, fire ies and glow-worms, click-beetles, metallic wood-borer beetles, staghorn beetles, leaf-beetles, palm-beetles, weevils, etc.

The tiger-beetles, so called because they are great hunters on the ground, are also called cicindelids. They are among the most easily recognized of our Coleoptera and are usually brightly coloured green, brown or black, with white bands and spots. They are generally about one or two centimetres long, with prominent bulging eyes. They have long, slender and sprawling legs, which enable them to run swiftly even on loose sandy ground. Though quite capable of flying, they seem to be happy running in pursuit of their prey in damp places, near rivers, paddy fields and sea beaches. The larvae of cicindelids live in vertical pits in soil and develop for a year or so, becoming adults after complete metamorphosis. Like the adults the larvae are predators that remain at the entrance to their pits and snap up any unwary insect that comes within reach. *Cicindela sexmaculata*, the six-spotted tiger-beetle, makes its home near paddy fields, where it hunts the paddy-bug *Leptocorixa variicornis*. The farmer should consider it as his inestimable friend. On our sea beaches, specially on the western coast, we find the four-striped tiger-beetle *Cicindela quadrilineata*, which feasts on the marine bug *Halobates* left by receding waves on sand.

The Carabids are permanently grounded beetles, which avoid flying if they can. Many of them are incapable of flight, because their elytra are completely soldered together on the back and cannot be opened out and because they do not have hind wings. They do

all their hunting on the ground and feed on various insects, especially caterpillars and grasshoppers, and also on snails. *Anthia sexguttata*, the large six-spotted black beetle is the most striking Indian Carabid of the plains and is wholly wingless. It is reported that when kept in captivity, a beetle feeds daily on one to two hundred grasshoppers. *Calosoma* is another of our fairly large-sized and wingless common carabids which has a beautiful steel-blue or sometimes even a coppery sheen. It feeds on snails and locusts. The most remarkable of our carabids is, however, the bombardier beetle, especially *Pheropsophus*. When threatened or disturbed, it explodes a malodorous and caustic volatile liquid with a loud report from its anal end and escapes, leaving its enemy utterly confused and overcome by the acrid fumes.

One of our prettiest beetles is the ladybird beetle found commonly on low bushes. There are several kinds of ladybird beetles in India, but all of them are nearly round or oval, finely pubescent, yellow, red or brown and black-spotted. Their larvae are usually spiny and yellow in colour. The beautiful seven-spotted ladybird *Coccinella septempunctata* is widely distributed both in the plains and on the hills and occurs at high altitudes on the Himalaya also. It is red coloured with seven conspicuous black spots of variable size and shape. Both the larvae and the adult of this beetle feed on different kinds of aphids. Immense mass assemblages of this beetle are often found under the protective shelter of snow on the Himalaya; one such contained nearly two million of them. Another common ladybird of the plains is the six-striped *Chilomenes*, a small yellow or reddish beetle, with black wavy stripes across the body. This is also a predator on aphids; a single beetle in captivity devours nearly two hundred aphids a day. On the leaves of the brinjal plant we find *Epilachna*, one of the largest of our ladybirds. It is dull reddish-brown with twelve black spots in *Epilachna duodecastigma* and twenty-eight spots in *Epilachna vigintoctopunctata*. It lays clusters of yellow eggs on leaves and its larvae scrape off layers of the soft tissue of the leaf as food.

The familiar glow-worms and fireflies are also beetles; the glow-

worm is the larva or the wingless and worm-like adult female and the firefly is the much smaller but winged adult male. Although common all over India, they are particularly abundant in moist and subhilly areas and in the plains during the wet season. The glow-worm is about 3 cm long, flattened and conspicuously plated, with an oval white patch below on the eighth abdominal segment. This patch is the luminous organ which emits light at the will of the insect. The light produced by the glow-worm is pale, greenish-white and cold. It is switched on quickly, but when shut off, it fades away rather slowly. As may be guessed, the glow-worm is nocturnal. It feeds on soft snails, consuming about half a dozen daily. Seizing hold of a snail firmly by the legs, the glow-worm curls over on its back and devours its flesh bit by bit. While feeding thus, it shuts off its light.

In the large and woody trees of our forests there are the lovely jewel-beetles (*pon-vandu*). They are large metallic-green insects, with red reflections and are often sold as curiosities by street hawkers. Their iridescent elytra are used as inlay in gem works. Among our jewel-beetles the most common is *Chrysochroa*, of which nearly twenty species are known. The larvae of these beetles bore inside tree trunks and take about a year to reach maturity.

A beautifully coloured beetle, which is often found in woods or which comes to light during the rains, is *Agrypnus*, the click-beetle. Most of this species are about a centimetre long, but some are nearly three times longer. They are all characteristically flat, and have below a peculiar stout spine-like curved prolongation from between the front legs, fitting into a small depression behind. The sudden movement of this prolongation enables the beetles, if thrown upside down by accident, to leap in the air with a peculiar clicking sound and land right side up. Their larvae are long attenuated creatures known as wire-worms, which feed on the roots of various plants.

The most abundant and very conspicuous beetles during the monsoon rains are the blister-beetles, also called cantharides. They are generally large insects, are very fond of bright sunshine, and

appear suddenly and mysteriously in great numbers with the first rains. They completely disappear till the next rains. We have several species of blister-beetles in our country. *Mylabris pustulata* is a large black-and-red-striped beetle, about two and a half centimetres long. It eats the pollen grains and tender petals of yellow flowers, sometimes orange and rarely light blue flowers. Its preferred flowers are those of the pumpkin, cactus, bitter-gourd, etc. *Mylabris phalerata* is about half the size of this beetle and has very similar habits. There are the blue blisterbeetle *Epicauta actaeon*, metallic-green blister-beetle *Epicauta tenuicollis* and a somewhat larger and brown blister-beetle *Gnathospathoides rouxi*. They feed on pollen grains and ower petals, tender ears of paddy, millets and other grasses. When disturbed, all blister-beetles exude from the joints of their legs an oily liquid droplet, which is yellow or orange in colour. This liquid causes painful blisters on human skin. The powder of the dried blister-beetles is used in the extraction of cantharidine for the manufacture of medicines and hair oils. They lay their eggs in soil before the cold weather and the larvae develop slowly, feeding on the eggs of grasshoppers or of Hymenoptera like bees, to whose nest they manage a free ride on the bees themselves.

The weevils or snout-beetles, of which there are many hundreds of species, have heads produced prominently in front into a beak. Most weevils are generally small in size, but the cocoanut-weevil *Rhynchophorus ferrugineus* is quite large. The female of this weevil deposits its eggs at the base of the leaf-sheath of cocoanut trees, particularly in cuts made by toddy-tappers. The larva, which hatches from the egg, tunnels into the soft tissues and makes a cocoon of cocoanut fibres before pupating. In doing so, it kills the tree. The damage is often very severe in South India. The largest and most remarkable of our weevils is *Cyrtotrachelus longimanus*. In the male of this species the front leg is very long, even longer than the whole body. It feeds on the juices of tender bamboo shoots; its larva tunnels inside a bamboo tree.

The most interesting Coleoptera are the dung-rollers or the scarab beetles, to which we have already referred in an earlier chapter.

The scarab is usually robustly-built ground beetle, black or brown and shiny with a wide shovel-like head. It often bears curiously-shaped horns above in front. Though the scarab can fly, it is a great walker, often covering great distances in a relatively short time. Unlike most other insects, it does not lay hundreds or thousands of eggs but merely one or two. However, its highly developed maternal and paternal solicitude protects its progeny. The scarab is popularly called the dung-roller beetle, because of its curious habit of rolling into balls the dung of sheep and cow.

The adult scarab is attracted from a distance to the freshly dropped dung of herbivorous animals by its powerful sense of smell. Arriving as if from nowhere, it scoops out by its shovel-like head a quantity of the dung, shapes it into a ball by turning it round and round with the help of its mandibles and legs. The ball is then pushed on the ground backwards, by the hind legs, the beetle itself moving backwards at the same time. Sometimes two beetles may be seen moving a ball together, one pushing it backward and the other dragging it. The ball is rolled long distances, often up to half a kilometre. There is sometimes keen competition among a number of beetles to secure the ball; several of them roll it, each in the hope of eventually appropriating it entirely to itself. The strongest, the most tenacious or the most fortunate one succeeds in the end. Bitter fights are also not uncommon for the exclusive possession of a dung ball. It is stolen if the rightful owner loses sight of it even for a minute. The ball is surprisingly big, often more than three times the size of the beetle that is rolling it. When at last a suitable spot has been found, the beetle stops rolling the ball, vigorously digs under it, and gradually buries it completely in the ground. The front legs are used in digging and the hind legs throw out the excavated mud. The ball is buried deep, often a metre and half below the ground; this involves tremendous patience and energy on the part of such a tiny creature. The buried dung ball serves as the brood-pear; the egg is deposited on it and the larva feeds on the dung. It develops for a whole year or even more before pupating. There are several dung-roller beetles in India; among the most common are *Heliocopris bucephalus* and *Heliocopris gigas* one- or two-horned

shiny giants; *Scarabaeus gangeticus* and *Sisyphus* with very long legs. The rhinoceros beetle is an interesting scarabaied, usually brown or black in colour, the head of the male being provided with a peculiar rhinoceros-like horn. It is found throughout the plains where cocoanut is grown. The adult beetles fly during the night and eat into the soft growing point of palms through the folded fronds. When the cocoanut frond opens out, it presents rugged holes. Often the single growing point is destroyed, thus totally arresting the growth of the tree and finally killing it. The larva, however, breeds in manure pits and in decaying vegetable matter. A beautiful group of scarabs is the cetonids or the chafer beetles. They are of moderate size with brilliant metallic colours, and diurnal in habit, visiting flowers to feed on the pollen grains and tender petals. Their larvae breed in decaying vegetable matter and roots or live in the nests of ants. *Naricius* and *Rhomborhina* are two of our common metallic-green cetonids, which occur generally near forest areas.

WASPS AND HORNETS

The mention of wasps and hornets brings to our mind memories of painful stings and angry buzzing of vicious insects. Our fear is wholly exaggerated because in truth wasps and hornets are entirely inoffensive creatures that rarely if ever attack man except in self-defence. Left to themselves, they ignore man and go about their business of building brood nests, gathering provisions and looking after their young ones. However, molest them ever so slightly, and hundreds of them will at once buzz over you and inflict painful stings which you will never forget. In many respects they differ from all other insects with which we have so far dealt. In the case of others the young ones do all the feeding and the adult does not generally live longer than necessary to lay eggs. Among the wasps and hornets, however, the business of life is done entirely by the adults and the larvae are totally helpless and dependent on their elders. The larvae do not hunt or gather food or build cocoons or even go out; it is the adult that does all these things for them.

The wasps and hornets belong to the Order Hymenoptera. There are many different kinds of them in our country. Some of them lead

a lonely life, but others are social insects. The colony of social wasps consists of queens, workers and drones. Some wasps are expert diggers, others are tunnellers in stone and still others are builders with mud, wood, paper, and other materials.

Of the social wasps common in India, *Vespa orientalis* and *Polistes hebraeus* may be taken as examples. The former is a larger yellow and reddish species and the latter mostly honey-yellow and smaller. Both are polymorphic and their colonies contain numerous individuals of imperfect females or workers, perfect females or queens and also males. Owing to their apparent ferocity and the virulence of their sting, they have not been studied properly in India. They build enormous combs of pure paper on trees, rocks and in abandoned buildings. The whole day long they work assiduously on dry tree trunks and wooden poles, stripping and tearing pieces of wood and fibre, having first moistened the spot with saliva. The fibres are then chewed thoroughly to a fine pulp, with which the geometrically precise hexagonal cells, hanging and open below, are made in horizontal combs suspended by a stout stalk. Several combs hang one below the other. *Vespa* covers all its combs with a paper envelope that leaves a passage all around adequate for movement and enabling the workers to have easy access to every part of their nest. The nests often attain big sizes of three-fourths of a metre in diameter and make stout branches bend with their weight. The wasps feed on caterpillars, praying mantids. bugs, grasshoppers, beetles, dead snakes and other meat. They are also extremely fond of fruit juices, syrup, candy, sugar, etc., and may be seen swarming in sweetmeat shops in our bazars. They feed their young ones with crushed meat brought by the workers.

THE BEES

The bees have been well known in India from time immemorial. The honeybees are social insects, but all bees are not; there are many species of solitary bees in our country. Not all bees gather nectar and produce honey; but all of them gather and store up pollen grains. The most common bees of India are the honeybees, the carpenter-bees and the bumble-bees.

Of the three species of honeybees found in our country, *Apis dorsata* is the largest and builds the biggest combs on trees, over-hanging rocky ledges and in tall buildings. It is the honey of this species that is gathered by forest people and sold in our markets. *Apis indica* is a medium-sized species that has been partly domesticated; in apiaries it builds its combs in wooden frames inside wooden hives. The smallest bee *Apis florea* builds a small comb in bushes. The honeybee gathers nectar and pollen grains from flowers. The nectar is partly digested in the gut of the bee and concentrated, with the addition of antiseptic preservatives. During the process of digestion, the different kinds of sugars present in the nectar are all changed to glucose. The honey is then regurgitated by the workers in wax cells, which are sealed by wax caps. The bees and their larvae feed on the honey and pollen.

The familiar giant non-social carpenter-bee *Xylocopa* tunnels in hard and dry wood. It is a large shiny black species, the male of which is covered by a soft yellow pubescence on the thorax. The carpenter-bee nests in wooden posts and beams. It is long-tongued, gathers pollen grains, but no nectar, and is of considerable importance in effecting the cross-pollination of flowers. It flies actively back and forth from flower to flower the whole day long and even at night when there is a full moon. It visits between thirty and forty flowers every minute.

The bumble-bees are confined to the Himalaya and nest underground and gather pollen grains. They are bulky and hairy bees with bright red or yellow colours.

PLATE XI *Top left* A Himalayan grasshopper basking in the warm sunshine on the leaf of the thistle plant *Top right* The painted grasshopper, *Poecilocerus pictus*, enjoying a siesta in the sun after a heavy meal on the leaf of the calotropis plant *Middle right* The beautiful red cotton stainer bug *Dysdercus cingulatus* mating on the leaf of hollyhok, the bug above is the female and the lower one is the male *Bottom* The Himalayan stick-insect, enjoying the sun on dry grass culms, observe that its legs and even its body are slender and stick-like. It is in harmony and at peace among dry grasses, where it has its home.

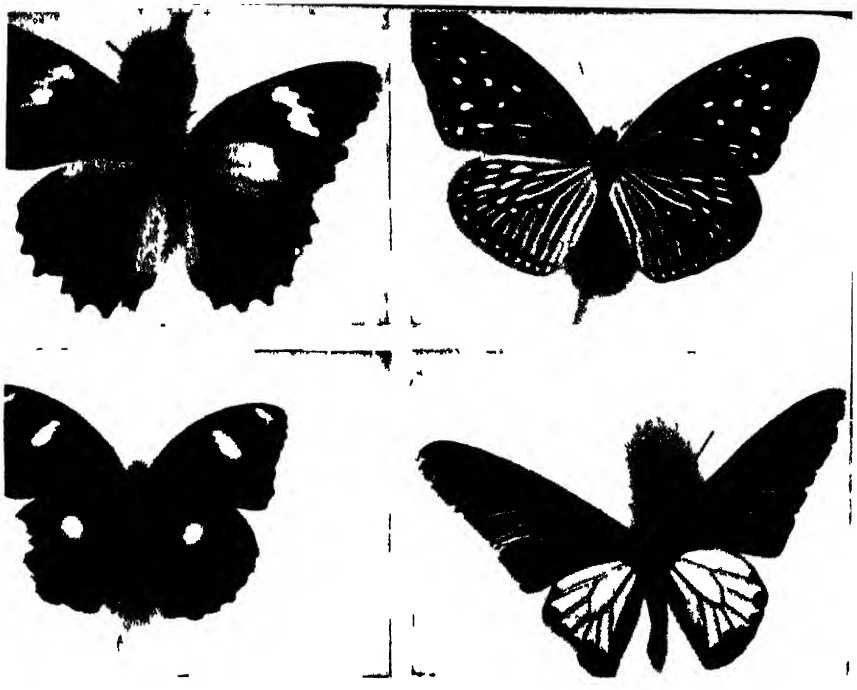

PLATE XII *Top left* *Hypolimnas misippus* female *Top right* *Danaus melissa* female *Bottom left* *Hypolimnas bolina*, male *Bottom right* *Cyrestis helena*, male

PLATE XIII *Top left* The male of the five-horned rhinoceros beetle from the Himalayan forests *Middle left*. The male of a rhinoceros beetle *Xylotrupes gideon*, also common in Himalayan forests *Right* The-metallic-green ground-beetles *Calosoma*, having perhaps a friendly exchange of news outside their burrows in bright sunshine *Bottom* One of our common Himalayan cicadas, with its beautiful wings spread out to show its wonderful colour patterns

PLATE XIV. *Top left* : A Himalayan apollo butterfly *Parnassius hardwickei hardwickei* that flies at elevations above 3000 m. *Top right* : A Himalayan fritillary *Argynnis* butterfly sleeping among leaves in the evening. *Bottom left* : *Eriboea dolon*, one of the beautiful butterflies of the Himalayan forests. *Bottom right* : The common lemon leaf butterfly, *Papilo demoleus* visiting flowers for nectar.

CHAPTER V

BUTTERFLIES AND MOTHS

INDIA IS a land of beautiful butterflies that add colour and charm to our sunny landscape and lovely moths that flit silently like angels from flower to flower in the calm of theevening. Our wealth of butterflies and moths is truly great and varied. The majority of them are not only harmless, but are also indispensable members of Nature. They are responsible for bringing about the cross-pollination of most of our flowers. It may even be said that flowers evolved or were created expressly for the special delight and benefit of butterflies and moths.

Butterflies and moths are at once distinguished from other insects by their large, colourful wings and the long coiled proboscis. The colour of their body and wings is due to the arrangement of minute, flat, thin, delicate structures called scales in definite patterns. They are placed by scientists in the Order Lepidoptera, a group of very recent origin, compared to the ancient orders of grasshoppers and cockroaches.

The Lepidoptera undergo a complete metamorphosis in the course of their development. The small and often exquisitely sculptured eggs are deposited on the leaves of the food plant of the caterpillar, a wingless, soft-bodied and worm-like larva that hatches from these eggs. The caterpillars are smooth or hairy, green, brown or black and feed voraciously on leaves, buds, etc. They rapidly grow fat and to keep pace with this growth, moult their skins a number of times. When fully grown, they become rather sluggish, stop feeding and seek some sheltered spot, where they spin a cocoon of silken threads. Silk is really the solidified saliva of the caterpillar. When the cocoon is ready, the caterpillar moults its skin once more inside it and becomes transformed into a smooth, motionless, mummy-like stage called pupa, which does not feed. On the surface of the pupa we may now notice indications of the legs, wings, etc., of the future butterfly. The inactivity of the pupa is

generally breed on palm trees and on bamboo leaves. They are attracted to toddy, sugary juices, horse dung, etc., and are not found among flowers. *Discophora lepida*, from Ceylon and Peninsular India, is a rare, large-sized, dark brown butterfly, with bluish-white spots.

THE NYMPHALIDS

The nymphalids are large, brilliantly coloured, tawny and black marked or spotted or striped butterflies, with tails on the hind wings. They are lovers of the bright sun and are powerful fliers. They visit flowers, though some often settle on dung, toddy or rotting fruits. *Charaxes* and *Eriboea* are the fastest-flying butterflies. All the nymphalids love to bask in the sun on leaves of trees and bushes. Their caterpillars feed on the leaves of a great variety of plants.

Charaxes, popularly called the *rajah*, and *Eriboea* called the *nawab*, are among the most beautiful of our butterflies. The rajah is usually tawny or chestnut-brown with markings, and the nawab is black above with a broad pale band or yellow or yellowish-green. These butterflies are most abundant in the north-east and are denizens of dense humid and warm forests. They do not visit flowers, but are attracted towards over-ripe fruits, rotting fruits and manure heaps. *Eriboea dolon*, the stately nawab, is found along the forested Himalaya from Assam-Burma to Kulu. *Eriboea schreiberi* is the blue nawab of the Western Ghats, Assam and Burma. *Charaxes polyxena*, the tawny rajah, occurs in Ceylon, South India and the Kumaon Himalaya from Assam to Burma. The robust, medium or small-sized emperor butterfly belongs to *Apatura*, some of which are dark brown, with white or tawny markings. *Precis* is a small but beautiful butterfly, blue, yellow, tawny or brown and with vivid eye-spots. *Precis hirta*, a bright yellow butterfly and *Precis orithyia*, a blue one, are very common in India, Ceylon and Burma.

Vanessa butterflies are coloured black, dark brown, scarlet, pink-red, marked reddish-brown and black spotted and are popularly known as the "painted lady". They love the open country and bright sunshine and are strongly attracted by showy flowers.

Vanessa cardui is the most common species and is widely distributed in Asia and Europe up to the Arctic Circle and in North Africa. In India, it is found in the plains and on the Himalaya up to an elevation of about 4,500 m above mean sea-level. This is a pinkish-red beauty with black markings and is 5-7 cm large. The caterpillar feeds on leaves of the thistle and various other Compositae and rarely on borages. It remains concealed inside a nest of silken webbing and folded leaf blade. The butterfly is well known for its migration. It loves open grounds and is a regular visitor to flowers. The Indian red-admiral butterfly *Vanessa indica* occurs in the hills in South India, the Himalaya and northern Burma. Though smaller, it is nonetheless beautiful, with its dark brown general colour and red central band and black eye-spots. Though eminently a butterfly of the forest, it is fairly common even in open areas. On the hills and mountains and particularly on the Himalaya, we find the fritillaries *Argynnis*, whose home is the grassy meadow. They are generally bright tawny, with transverse lines of black spots above and silvery spots below and stripes underneath. *Argynnis hyperbius* occurs in Ceylon, the Indian Peninsula, the Himalaya and North Burma. Though typically a mountain butterfly, it migrates to the plains during winter.

The Lycaenids

These are generally small butterflies, with a predominating blue colour and with the wings spotted and delicately tailed. They are remarkable for their pronounced myrmecophily; their caterpillars regularly occur in the nests of ants which look after them and they give to the ants in return a sweet secretion as food. The butterfly often seeks the nest of ants for laying its eggs or the ants carry off the caterpillars to their nests and keep them and even build shelters over them, just as we build cow-sheds. Perhaps the commonest lycaenid butterfly is *Euchrysops nejus* that occurs throughout India, Burma and Ceylon. It frequents the flowers of various garden plants and is very fond of drinking water from damp places. The caterpillars live on leguminous plants. *Virachola isocrates* is another common dull violet-blue coloured lycaenid, the

caterpillars of which live in pomegranate, guava and tamarind fruits.

The Papilios

Swallow-tail butterflies are among our largest and most beautiful insects. Though mostly black or brown, their beauty is enhanced by varied colour markings with red and yellow. The hind wings have a long tail in many species, and hence the name swallow-tail butterfly. They are common in forests, in the plains, hills and mountains.

Troides helena is a beautiful shiny black species, with golden-yellow above. It is common along the Western Ghats in South India and reappears in Orissa, Assam and Burma. It has a partiality for visiting the flowers of the common lantana. *Polydorus aristolochiae*, common during rains throughout India, is black with white or red spots and is the largest of our swallow-tails. Its caterpillars feed on leaves of aristolochia. The adult butterfly visits all kinds of flowers. The other common Indian swallow-tails are *Papilio polymnestor*, *Papilio bootes* and *Papilio demoleus*. The well-known kaiser-i-hind butterfly *Teinopalpus imperialis* is confined to the Eastern Himalaya, Assam and Burma. It is about 10 cm large, rich green with black, bright yellow, lined and tailed.

The apollo or *Parnassus* butterflies of the Himalaya have their homes amidst snow and are rarely, if ever, found at elevations below 3,000 m above mean sea-level. Apollo butterflies occur also in Europe, northern Asia, North America and in the Arctic lands. They are white diaphanous butterflies, with very few scales on their wings which are marked by black bands and red spots.

The Pierids

These are moderate-sized butterflies, mostly white with some shades of yellow or orange. The caterpillars of *Pieris* breed on the leaves of cabbage, mustard and other Cruciferaceae or sometimes Capparidaceae. The caterpillars of the yellow-coloured *Colias* breed on leaves of Leguminosae. *Delias eucharis*, common in Ceylon, India and North Burma, are about 8 cm large, white with black lines. *Ixias pyrene* is yellow and black and occurs in Ceylon, Peninsular India, Bengal, the Himalaya and in Burma. *Catopsila*

crocale and *Catopsila pomona* are pale yellow or white-coloured butterflies common throughout India, Ceylon and Burma.

MOTHS

The great majority of our moths are small and though many of them are of considerable beauty, they generally escape our notice and remain unknown even to the specialist. This is largely because of their nocturnal habits.

Not all moths live out-of-doors; some are found inside our homes. *Tinea pachyspila*, *Tinea tapetzella* and *Setomorpha rutella* occur, for example, in nearly every home; their caterpillars eat the wool in our wardrobes. Many moths, the caterpillars of which live out-of-doors on various plants, regularly visit us at night, attracted by lights. The chief among these are noctuids and hawk-moths. There are also Saturnids and Bombycid moths that come to light occasionally.

The hawk-moths which also come to light, especially soon after the monsoon rains, are the most easily recognizable among our moths. Their torpedo-shaped bodies and pointed wings and the high speed they attain on flight are unmistakable. Some of them have a wing-span of nearly 10 cm. All have an unusually long proboscis which can reach down to the nectaries which are concealed cleverly at the bottom of long tubular and sweet-scented flowers that open in the night. Their caterpillars are plumpy, smooth, green or brown, with conspicuous eye-spots and stripes, which can be retracted and concealed under folds of skin. Some of them are also armed with fleshy horns behind. They are perfectly harmless. When alarmed, they raise the front of their body and remain motionless like a sphinx—hence they are also called sphingid moths. Not all the sphingid moths fly at night; some fly during daytime in our hill stations. Among the more common and beautiful sphingid moths are *Herse convolvuli*, a large grey-coloured species with pink bands on the abdomen and *Acherontia styx* the so-called death's-head moth. It is reddish coloured with yellow and blue spots on the abdomen and a marking on the thorax which has a fanciful resemblance to the conventional

skull and crossed bones (hence the name death's-head moth). The large, plumpy green caterpillar feeds on the leaves of sesamum and beans. *Deilephila nerii* is a dark olive-green and pink-coloured moth and is perhaps the largest of the three species mentioned here. Its caterpillar feeds on leaves of oleander. *Macroglossum* is the dark-coloured humming-bird moth that visits flowers in the hills. *Hippotion* is the common hawk-moth of the plains.

The noctuid moths are extremely common and many of them have proved to be of great importance in agriculture, but the great majority of them are small and cryptically coloured and thus generally escape notice. Their caterpillars feed on the leaves of diverse plants and the pupae often occur underground. The best known, particularly because of their large size and attractive colours and markings and because they are strongly attracted by light, are the fruit-sucking moths, *Ophideres*, with characteristic yellow hind wings and red eye-spots. Their caterpillars feed on the leaves of a variety of wild plants and at night the adult moths visit ripening fruits of orange, lime and mango, puncture their skins and suck the juice.

The saturnids are wild silkmoths, brightly coloured and of immense size, attaining a wing span of 25 cm in the famous atlas moths. Owing to the absence of the proboscis, they are incapable of feeding, and are mostly nocturnal and short-lived. They are all typical denizens of forests, particularly of dense, humid and tropical forests. A curious feature is that in the forest a female moth attracts crowds of males from considerable distances. *Attacus atlas* the atlas moth, *Attacus cynthia* the wild silkmoth of the castor-oil plant from Assam *Actias selene* and *Antheraea paphia* the tussar silkmoth are the best-known saturnids of India. *Actias selene* is very striking in its appearance, because of the long curved tail of the hind wing and the delicate pale green colour and the red crescent-shaped eye-spot. The atlas moth is the largest of the Indian moths. The tussar silkmoth is not domesticated; the silk obtained from its cocoon is collected from wild plants in the forest.

CHAPTER VI

INSECT LIFE IN OUR HOMES

INSECT LIFE in our homes is entirely a creation of man himself. It is an artificial life for the insect, whose original home is out-of-doors. The nearest relatives of all our household insects, including the highly specialized synanthropous species like the bedbug, live out-of-doors even today. Though we seem to have a horde of insects indoors, the truth is that only a few species have learnt to take advantage of the extra shelter, the uniformly favourable conditions and the comparative luxury of living with man inside his house. Those which have chosen to do so have, however, suffered inevitable degeneration in a number of ways. Their adventure has not been a blessing either to them or to man, though it is not all curse to the latter. Paradoxical as it may seem, the domestic insects in India show a decided partiality for urban homes, with the result that city homes are more insect-infested than village homes. The simple hut of the Indian village offers little that could attract the insect from the field and the garden, where they have lived since the beginning; it is merely another part of the field with nothing special about it. The case is, however, different in cities. Our "modern" homes, in industrial centres and factories, are man's standing invitation to all sorts of insects to acquire new habits and to cultivate a taste for strange and unusual foods. Some insects have accepted this invitation on a permanent non-payment basis and others simply come in occasionally when they are so inclined, but do not stay permanently. We do not by any means say that there are no insects in our villages; the few that occur are really the outdoor insects which stumble indoors and do not really belong there. It is necessary to emphasize, therefore, that only a few species, if at all, have specialized for exclusive life in village homes. On the other hand, in our city homes are found insects that have actually and truly evolved there, only occur there and nowhere else, and are highly specialized and adapted to live with man. They are well-

established forms that have become so thoroughly attuned that they do not and cannot attempt any "getting-away-from-it-all" even for a change, like our citizen who with his angling rod or golf clubs often pretends to do so. The man in the city is under the delusion that his cleaner home, with greater amenities, has fewer insects than that of the backward villager.

What are the special features of the insects which live exclusively with man in his home? It may be stated again that as a class insects are lovers of the open air and sunshine and green vegetation. But the household insects shun sunlight, are afraid of exposure, have no special liking for green vegetation, and like darkness and filth. Their powers of locomotion are generally limited; their wings and legs are on the whole rather poorly developed when compared with those of the outdoor forms; their sense organs are not so powerful and efficient. They have been so long with man that many share bad human traits. They reflect the habits of the master of the house in which they dwell. From the insects of a household one can almost say what sort of people dwell there.

Though the list of our domestic insects is long and varied, we shall confine ourselves only to the rigidly synanthropous houseflies, cockroaches, crickets, silverfish-insect and the bedbug. These are the unavoidable by-products of human civilization. You may perhaps wonder why we have not included the mosquito that torments us every night. The answer is that the mosquito is not a household insect; it is only a nightly visitor, which prefers to live outside so long as it gets its blood meal.

The Housefly

"Behold the housefly—He is hideous, dirty, monumentally stupid, with the germs he carries, he is also a killer" cries a recent article in a most fashionable and widely-read monthly journal of international coverage. These are terribly harsh words, but alas they merely show how ignorant the modern educated man makes himself in his assumed superior wisdom.

There is a popular belief particularly among our fashionable city folk that the houseflies are dirty creatures. This is wholly

untrue. Believe it or not, the housefly is one of the cleanest creatures on the earth. It keeps its body scrupulously clean and free from dirt and other foreign matter and spends more time on its toilet than any of us ordinarily do. When it is not buzzing and feeding, the housefly's primary occupation is rubbing with its legs, the wings, eyes, head and indeed every part of its body even though there may be not a speck of dust on it. It is almost an obsession with the housefly to keep itself clean.

The housefly is certainly not hideous. Look at it through even a small and cheap magnifying glass and you will see the marvel of its perfect symmetry, the beauty of its patterns, the matchless compound eyes, the iridescence of its delicate wings. It is a harmony and rhythm of shape, size and colour, a music of geometry. Lastly, to call a housefly monumentally stupid sets the final seal on our own ignorance. The housefly has enough brains and special senses to emerge successful under the most challenging conditions of life. It knows precisely how to fly, how to land erect or upside down, where to find food, where to lay its eggs and how to avoid your attempts to squash it. It does not have to go to a university to learn how to do all these things. It can remain air-borne for hours on end or land without having to touch down on a runway. The buzzing sound of the fly is due to the beats of its wings—200-300 times a second! Observe the fly land on the ceiling of a room after a flight. How does it do it ? Is it a halfroll or an inside loop in mid air ? If you are an aeroplane pilot, try to figure it out; it is still an unsolved mystery. Its safety depends wholly on its alertness the acuteness of its vision and its ability to be off like a streak of lightning.

A housefly cannot eat solid food like the grasshopper and cannot suck liquids like a bug or a butterfly. It can only sponge its nourishment from moist surfaces. If the food is dry, the fly will first moisten it with its saliva and then lick the moistened area. The original and natural food of the housefly is fermenting vegetable matter, especially the dung of herbivores. The eggs are deposited in decaying vegetable matter and in farmyard manure. From these eggs hatch in a day or two pale yellow, legless worms called maggots.

The maggots feed on the decomposing manure, dung or vegetable matter. They are important scavengers which help in the quick disposal of filth. They become full-grown in four or five days and turn into cylindrical brown pupae, 5 to 7 cm below the ground in soil. The adult flies emerge from these pupae in another three or four days. The total life cycle of the house fly is thus completed in about a week, depending upon the atmospheric temperature, the most favourable being 33°C. The adult fly may live for about a month during summer and almost for three months during winter.

Though the flies normally breed in manure and other decaying vegetable matter, the adults are powerfully attracted to filth accumulating around human settlements and also to exposed human food. It is thus that flies spread the pathogens of cholera, typhoid and dysentery. It seems ironical that breeding in decaying matter and keeping its own body clean, the housefly should spread the organisms that give rise to fatal diseases in man. For this, man himself is wholly responsible: for it is he who creates the insanitary conditions in Nature. The bigger the crowd he lives in and the more civilized his settlements are, the worse are the filth and insanitation that he creates in Nature and the greater the chances of weaning away the flies from their natural abodes to spread contagion and infection.

Musca domestica is the cosmopolitan housefly of the civilized world including India. Others include *Musca nebulo*, the most common housefly of India and *Musca vicina*, a smaller fly frequenting our homes.

The housefly has numerous enemies like lizards, birds, monkeys, etc. It suffers high mortality from epidemic diseases caused by fungal parasites. It is attacked by parasitic mites and nematode worms. The annual mortality rate in the housefly is incredible—99.6%—and yet it multiplies by billions, thanks solely to the human aid-the-fly programme.

The Cockroach

The cockroaches belong to an ancient group of insects; the oldest fossil cockroach belongs to the geological ages more than two

hundred million years ago. The floor of the primeval humid and warm forests of those distant times (when most of our deposits of coal were being laid) was populated by truly giant cockroaches. Even today most cockroaches live under fallen leaves in humid tropical forests, but some species have invaded human dwellings and have been carried all over the world in his ships, trains, etc. The so-called American cockroach *Periplaneta americana* is a true citizen of the world and occurs in every home, factory, store, train and ship. It is a large, flat, dark reddish-brown shiny creature that runs swiftly, shuns light and exposure, loves warmth, humidity and contact and eats almost anything that could possibly be eaten. It hides in drain pipes, latrines, kitchen, pantry, among bags of grains and flour, in old and undisturbed book shelves, in wooden boxes, etc. During some warm and oppres ive nights before an imminent rainfall, it takes to the wing and flies out in swarms. In some parts of South India this flight of the cockroach is believed to be a reliable weather forecast promising rainfall. This habit of the house cockroach lets out the secret of its ancestral out-of-door existence in the dim past before man compelled it to come inside; it is the relic of the instinct of the open-air animal, which flew in begone ages to a place of safety before a heavy downpour. In temperate and colder countries the cockroach avoids flight altogether.

The cockroach lays about two dozen eggs inside an ootheca, curiously resembing a miniature Gladstonebag. The young nymphs are active creatures which generally resemble the adult. *Blatta orientalis* is a somewhat smaller cockroach that has similar habits and distribution. Cockroaches move in filth, but keep their bodies clean, like the housefiies, spending all their leisure time on toilet.

Though they do not attack man and generally keep themselves out of his sight, they taint everything that comes into contact with them with their obnoxious smell. They also mechanically contaminate articles of human food with pathogens of diseases. Occasionally a cockroach may nibble away the delicate hairs in the eyebrows and the tender skin of the head of new-born babies and thus cause painful sores. Cockroaches have many enemies, primarily moles,

lizards and birds. They are heavily parasitized by many parasites, especially Protozoa, worms and insects. The ensignfly *Evania appendigaster*, a black shiny insect that waves its abdomen up and down like a signal flag (hence the name) is parasitic on the eggs of the cockroach. In China cockroaches are considered a delicacy; a medicinal "tea" is also brewed with the cockroaches in boiling water as a cure for certain diseases.

The Cricket

As already pointed out, the crickets are burrowing creatures of the garden and field; however, at least one cosmopolitan species, the house cricket *Gryllus domesticus* lives almost exclusively with man as a permanent guest in his house. It is a moderately large, pale brown and agile fellow that shuns light and hides the whole day behind warm fire-places in cracks and crevices in kitchen and pantry. It comes out at night to feed, meet friends and chirp for sheer joy. Usually it is satisfied with left-over food particles and crumbs, but does not hesitate to nibble at whole bread, cakes, potato and brinjal and any other food material. Like the cockroach, the cricket may also occasionally nibble the hair and skin of new-born babies. Depending upon atmospheric temperature, the house cricket chirps for hours on end in its characteristic manner so well known to us. Like the ubiquitous cockroach, the cricket has also been widely distributed by man. Both the cockroach and the cricket are part of the blessings of the rapid means of travel by man, though of course he did not bargain for them.

The Bedbug

The most loathsome of the degenerate insects, which have chosen to live in companionship with man, is unquestionably the all-too-notorious bedbug *Cimex*.

The bedbug is a wingless, flattened, reddish-brown creature, with a rounded outline and looking like an unhusked lentil seed from a distance. It shuns light, loves warmth, humidity and contact and hides during the day in cracks and crevices in walls and in furniture. At nightfall it sallies forth to puncture the skin of man and drink

his blood. When fully gorged, it leaves him in temporary peace for its place of concealment leisurely to digest the bloody meal.

It is strongly attracted by the warmth and odour of the sweat of the human body and is by no means averse to biting him even during daytime, as any of us can testify from personal experience of third-class travel in a railway carriage. It is also one insect that does not show any partiality for urban or rural homes, but is equally happy in any situation, provided man can be found. Not the least part of the detestability of the bedbug is its peculiar and penetrating stink.

We have heard many incredible stories about the marvellous capacity of the wily bedbug. Unfortunately some, if not all, are only too true. A bedbug can survive hunger for three to six months. It can migrate across an adjacent vacant house in order to gain access to an occupied one, overcoming apparently insurmountable barriers. If denied easy access to beds by the legs of our cots being placed in troughs of water and kerosene, the bug is said to climb up the wall of the room, thence crawl to the ceiling and from there drop down on the unsuspecting sleeper below to suck his blood with full vengeance.

It is not, however, quite correct to throw all the blame on thebedbugs; for it is man who carries them from city to city, village to village, all over the world in his carriages, trains and ships. The railways carry them as ticketless travellers, with free meals served at their seats during the journey.

The association between bedbug and man is as old as man himself. To begin with, we must note the fact that the bugs had not learnt to drink human blood before man stood up on his legs. Like all its nearest and closest kith and kin, the bedbug was originally and primarily an ectoparasite on bats in their caves. When the first man sought shelter from cold and exposure inside caves, which were full of blood-sucking batbugs, the batbugs found a vulnerable victim and perhaps his blood also tasted better; no doubt he smelt stronger than the bats hanging upside down from the roof of the caves. The "bat" bug thus became "bedbug"; later man brought them with him to the home he learnt to build for himself. The bedbug thus evolved simultaneously with man. Having taken

shelter in bat-caves, why must man blame the batbug if it became his bedbug? By dropping on your bed from the ceiling of your bedroom, the bedbug is merely following the ancient tradition: falling from the roofs of bat-caves to the floor to attack man huddling there.

We have in our homes two almost indistinguishable species of bedbugs, viz., *Cimex lectularius* common throughout India and abroad and *Cimex rotundatus* of Europe and North India. The habits and life-histories of both are more or less similar. They deposit their eggs in crevices and the tiny young, pale-coloured bugs that hatch from them in about a week are capable of sucking blood directly afterwards. They even suck blood from the older bugs, which may be already gorged with human blood. As they grow up, the young ones moult five times and become sexually mature adults in about eight weeks. At the time of sucking blood, the bug injects its saliva into the wound. This causes painful irritation and prevents the clotting of the blood, enabling the bug to suck a mixture of liquid blood and saliva. If a bug is unable to get a blood meal, its development is slowed down; its life is actually prolonged by starvation.

Bedbugs are not definitely known to transmit any human diseases. It is also curious that the bedbug does not appear to have any natural enemies; at least we do not know of lizard, bird or any other insect attacking the bug. The bedbug is *persona non-grata* for all other Indian insects and it seems to like it that way.

The Silverfish Insect

The silverfish insect *Lepisma* is an urban-home dweller, whose closest cousins still live on rock and stone, the bark of trees and under fallen leaves and do not show an inclination to come inside. It is tiny, fancifully fish-shaped, shiny-silvery coloured and somewhat flattened, and found in dark, warm and humid corners, behind pictures on walls, wall paper, old and undisturbed books, etc. It feeds on starch, sizing and paste used in binding books and it eats holes into paper. When disturbed or suddenly exposed, it runs swiftly to hide itself. The silvery colouring is easily rubbed off as a

fine grey powder, because of a coating of tiny overlapping scales on the body. The silverfish insect has no wings, but is provided with three long tails.

CHAPTER VII

INSECT LIFE IN OUR INLAND WATERS

THE ANCIENT INSECTS were amphibiotic—their infancy was a prolonged aquatic life and their brief winged adult life was aerial. The modern insects are mainly terrestrial and air-breathing, though many have invaded and colonized fresh-waters and seas and have become secondarily aquatic insects.

India is rich in inland waters—rivers, streams, ponds and lakes. These waters are densely populated by a most diversified and extremely interesting class of aquatic insects They include mayflies, stoneflies, dragonflies, cockroaches, bugs, beetles, sialids, caddisflies, mosquitoes, gnats and other flies, springtails, etc. Some are aquatic only as larvae or as pupae, but terrestrial as adults, while others are aquatic both as larvae and as adults.

Air-breathing terrestrial insects have to face many unexpected difficulties and problems if they were to become aquatic. Some are complex and concern locomotion in water and breathing when submerged. All aquatic insects have solved them efficiently in different ways. The majority swim with the help of their hind legs, which have become specialized to function as oars. Many swim by jet propulsion mechanism by forcibly expelling water from the anus. Though living in water and diving under the surface to the bottom, many aquatic insects depend on atmospheric air for breathing. They carry a supply of air when they dive into the water and by periodically rising to the surface replenish the supply of air before diving again. They have developed special organs for tapping the atmospheric air, and for carrying a supply of fresh air with the body even when under the water. Most other aquatic insects breathe by gills like fishes; utilizing the oxygen dissolved in the water; they are independent of the atmosphere. Unlike the gills of fish, those of most insects contain fresh air and not blood. The oxygen dissolved in the water is taken in by osmosis in exchange for the carbon dioxide of the blood.

Many aquatic insects have a highly developed eyesight and their compound eyes have two well differentiated parts, the upper part specialized for vision in air above the surface of the water and the lower part adapted for vision under water. Though they live in water, the body is not wetted, because it is coated with a water-proof waxy layer. Aquatic insects feed on water plants, decaying organic matter in the water or on other animals which live in water; some of them hunt the terrestrial creatures that come to drink water.

A large number of insects are semi-aquatic and live habitually at the water's edge on the banks of rivers, streams, ponds and lakes. Periodically they sally forth into the water for hunting, drag the victims to the bank and devour them. Numerous insects are capable of walking or skating expertly on the surface of a pond or lake, without floundering or breaking the surface. They succeed in doing this by utilizing the forces of surface tension of water. A large number of other insects are truly aquatic in that they dive and swim great distances under water; many also habitually lurk at the bottom and avoid rising to the surface.

As a rule the surface dwellers inhabit stagnant waters and the divers inhabit both stagnant and running waters. The inhabitants of running waters are among the highly specialized and are provided with a variety of complex organs for securing firm anchorage to the substratum so as to prevent their being washed away by the current. They effectively utilize the current itself to bring them fresh supplies of food and oxygen and, therefore, move very little from place to place. Some of the inhabitants of running waters construct protective cases of stones, sand grains, sticks and other suitable material and live inside them. The aquatic insects of India present many unsolved problems of fundamental importance in biology and offer infinite scope for observation, even purely as a hobby. They are excellent objects for rearing in small aquaria in our drawing-rooms.

INSECT LIFE IN PONDS AND LAKES

The ponds, lakes and other stagnant waters are the homes of two great groups of aquatic insects, viz., the surface-haunters and the divers.

THE SURFACE-HAUNTERS

They are the common water-striders, water-skaters and whirligig beetles which rarely, if ever, dive below. They walk and run with great speed on the water surface. Most surface-haunters are gregarious and show a decided partiality for open waters, particularly in the shade of a tree on the shore.

The water-striders and skaters are true predatory bugs, with well-developed wings and are capable of flying occasionally. They have long antennae and well-developed compound eyes. Their legs are long, hairy, slender and coated with a water-proof secretion so that they do not break the surface of the water. *Hydrometra vittata* is a striking elongated insect, common in most ponds. Another surface-bug is *Gerris*, which has the hind legs much longer than the rest. These two bugs merrily run about together and skate on the pond surface throughout the hours of sunshine.

Perhaps the most interesting of the surface-haunting insects are the whirligig beetles (Gyrinidae). They are at once recognized by their rapid going round and round in complicated circles on the surface of the water. They are small, shiny, black, compact insects, with short antennae and compound eyes divided into an upper half for vision in air and a lower half for vision under water. Their front legs are long, with a dilated pad (sucker) in the male. The middle and hind legs are short and flattened and serve as paddles for swimming. The part of the body that is partially submerged in the water is covered by pubescent hairs. The larvae are bottom-dwellers and breathe by means of gills. *Orectocheilum gangeticum* is the common whirligig beetle of the plains and *Dineutes indicus* is a larger species found both in the plains and in the hills.

THE DIVERS

The divers in our ponds, tanks and lakes include many diverse creatures; we have among them both the aquatic larvae of typically aerial adults like mayflies, stoneflies, dragonflies, caddisflies and mosquitoes, as well as numerous others which are aquatic throughout their life, such as the water-boatman, water-scorpion, corixids, notonectids and the naucorid bugs.

The mayfly larvae are truly aquatic insects, which breathe by means of tracheal gills, borne one on either side of each abdominal segment. They live completely submerged in the water and feed on algae, diatoms and other aquatic plants and grow rather slowly for several months. The adult is a delicate insect incapable of feeding and lives hardly for a few hours. Its stomach and intestine are filled with air to increase the general buoyancy of the body during flight. As soon as the adults emerge from the water, they rise in swarms in the air, perform the nuptial dance of rising and falling in air, come together in pairs and mate while still air-borne. The male dies soon afterwards, and the female seeks the water to deposit her eggs and then she also dies.

The aquatic larvae of the dragonflies are powerful predators, provided with an extensible lower jaw, bent double like an elbow joint and toothed and sharply hooked at the tip. The modified lower jaw is called fang-mask and serves as a terrible trap for capturing prey. The larva lies usually motionless and when an unwary prey comes within striking distance, the fang-mask is shot out with the speed of lightning. The victim is caught between the teeth and hooks. Retracting the fang-mask with the victim, the larva eats its meal at leisure. It breathes by means of gills, which also serve as tails and rudders. It swims forward with a sudden jerk, using the jet propulsion mechanism of forcibly ejecting water from the anus.

The adult dragonfly is a large, conspicuous aerial insect that loves bright sunshine and is an exceptionally good flier. Many of our dragonflies are beautifully and brightly coloured and spotted and sometimes also iridescent. Many of them are giants having a wing span of nearly 10 cm. They all have immense eyes

and indeed their head is nearly all eye. This enables them to see tiny mosquitoes and gnats in the air and swoop upon them. The legs are armed with stiff and long bristles and are used in clinging to some support when the dragonfly alights after a long flight and also as a sort of open-mesh basket to hold and transport mosquitoes and other insects when flying; sometimes as many as one hundred mosquitoes may be carried in this manner. The more common dragonflies of India are *Orthetrum, Gomphus, Libellula* and *Agrion.*

Aquatic Bugs

The aquatic bugs live in water both as larvae and as adults. The adult bugs have well-developed wings and they also often fly towards light at night during the monsoon rains, or soon afterwards. They are voracious predators that suck the body fluids of many kinds of insects or the blood of men, fish, tadpoles and frogs. In nearly all of them the front legs are modified into powerful clasping organs, fitted for capturing and holding the prey during blood sucking. The hind legs are admirably adapted to function as paddles for swimming. They rise to the surface of water for renewing their supply of air for breathing at regular intervals.

The most common of our water-bugs are the water-scorpions, corixids, back-swimmers and giant water-boatman.

The water-scorpions *Laccotrephes* and *Ranatra* are so called because their forelegs look like the powerful raptorial claws of a scorpion; to complete the resemblance, they have also a long tubular tail. This tail is really a siphon that helps them in tapping the atmospheric air at the water surface for a fresh supply of air for breathing. *Laccotrephes* is the typical nepa or water-scorpion of India. It is a flat and rather dingy coloured bug, with straight parallel sides and stout and hooked forelegs. The siphon conducts the air to the capacious air space between the back and the wings; it is into this air space that the spiracles (the external openings of the tracheal tubes) open so as to facilitate respiration. *Ranatra* is a slender bug, about 4.5 cm long. The corixids are small bugs, with short forelegs and are strongly attracted by light in swarms after the monsoon; sometimes one can collect basketfuls within a couple of

hours under an electric light. The notonectids are also small bugs which, curiously enough, swim upside down (hence their name back-swimmers). *Belostoma indicum* or the giant water-boatman (also called the toe-biter) is one of the largest bugs in the world. It is a flat, dark green creature, with the fore legs modified as raptorial organs and the other legs serving as paddles. It can bite even human beings most viciously and generally sucks the blood of toads, frogs, tadpoles and fish. It is often attracted in great numbers to light. *Sphaerodema*, a common bug of most ponds, is remarkable for the fact that the male carries the eggs till the young bugs hatch.

Aquatic Beetles

The dytiscids and hydrophilids are our important aquatic beetles. The former are mostly oval-bodied insects that carry a supply of fresh air between the elytra and the trunk. They are carnivorous and often fly at night. *Cybister confusus* is a large black beetle, striped brown at the sides, and found commonly in fresh waters throughout India and particularly in paddy fields. A smaller and more common species is *Eretes sticticus*, whose larvae feed on the larvae of mosquitoes. The hydrophilids generally resemble the dytiscids, but are mostly vegetarians. *Hydrophilus*, *Hydrous* and *Berosus* are common in paddy fields, tanks and ponds.

Caddisflies

The adult caddisfly is an aerial, moth-like insect that prefers to fly at dusk or night. A caddisfly is recognized by the conspicuous hairiness of its wings and the absence of a coiled proboscis. It is sombre coloured and inconspicuous, and is of interest mostly to the specialist.

The larva of the caddisfly is, however, better known than the adult; it is the aquatic caddis-worm. It presents some of the most intriguing problems in habits, instincts, adaptation and animal distribution of fundamental importance in biology and animal psychology.

The caddis-worm is remarkable for the construction of a silken-

thread-lined cabin of pieces of sticks, bits of leaves, chewed plant fibres, sand grains, small pebbles of selected sizes and mosaic of colours, small molluscan shells, etc. It lives inside the cabin permanently, and what is more interesting, carries its cabin wherever it goes.

The caddis-worm is a delicate caterpillar-like larva, with three pairs of true legs on the thorax and a few filamentous and delicate gills for breathing. Its tail end has a powerful hook, by which the larva anchors itself to its case. At the slightest disturbance, the caddis-worm withdraws itself completely within the case and closes the opening tightly from within by drawing the silken webbing. It is now well protected from all dangers. As it grows in size, it enlarges its case. It varies the shape, weight and the material used in the construction of the case so as to suit not only its own age and size, but also the nature of the water in which it lives, whether stagnant, flowing slowly, or a torrent. In tanks, ponds and lakes and other stagnant waters or in streams flowing slowly, it constructs its case of comparatively lighter material like plant fibres and small thin sticks, cut expertly to a uniform size and neatly arranged and tied by silken threads to prevent the case from collapse or crushing. In running waters or in ponds where the water is liable to be violently agitated, it makes its case out of relatively heavier material like small pebbles as a guarantee against being carried away by the current and also to minimize damage caused by being knocked about by the waves. The case is mostly cylindrical, but wider in front than behind so as to permit the stouter front end and the head being thrust out. Some cases are square in cross-section. It is open in front and closed behind at the narrower end. Many species of caddis-worm are gregarious and construct communal silken tents in rivers and irrigation channels. These tents also serve as snares for trapping the prey. The caddis-worms feed on algae, diatoms and other aquatic plants; they are also carnivorous and hunt the aquatic larvae of other insects. They are extremely common in paddy-fields, tanks, ponds, lakes, reservoirs, irrigation canals, streams, rivers, etc., throughout India and may be found abundantly in the plains, hills and on the Himalaya.

MOSQUITOES

The familiar mosquitoes are true aquatic insects in their infancy. While the adult mosquitoes are aerial insects which rest in dark corners during daytime and fly out at night in swarms for sucking blood, the larvae and pupae live entirely in water.

The larvae and pupae of mosquitoes may be found in almost any collection of water, however small and temporary it may be; they live and develop freely in ponds, muddy puddles of rain water, collections of rain water in holes in trees, wells, tanks, lakes, drains, canals, streams, rivers, etc. Although the larvae are aquatic in every sense, it is remarkable that they breathe atmospheric air directly. In order to obtain a fresh supply of air, the larvae and pupae rise to the surface of the water and remain suspended from the surface film. A short tube or siphon at the tail end of the body, provided with a fringe of fine water-proof hairs spreading out on the water surface and keeping the mouth of the siphon open and thus placing the siphon cavity in communication with the air, serves as the respiratory organ. The larva swims by the lashing movements of its slender abdomen. It has a brush-like structure near its mouth, with which it sets up a current of water, drawing the food particles into the mouth. It feeds on dead organic matter, algae, micro-organisms and other small solid particles. Some larvae are cannibalistic and attack the smaller mosquito larvae and still others are predacious on the larvae of gnats and midges which also breed in water. The mosquito larvae grow rapidly, moult three or four times and then turn into a short, stout, hunch-backed or comma-shaped pupa. The mosquito pupae are provided with horns on the back of the body in front for tapping the air from the atmosphere; in this process they rise to the surface of the water. They swim by the paddling action of their tail fins.

Two classes of mosquito larvae are generally found in our inland waters, viz., the culicine and anopheline. The anopheline mosquitoes transmit the malarial fever of man, monkey and birds and the culicine mosquitoes transmit filariasis in India and yellow fever in other parts of the world. It is only the female mosquito that bites and sucks blood. The male is usually either incapable of feeding or

it may suck plant juices. In condemning the malarial mosquitoes as enemies of man, we forget that the anopheline mosquito is as much a victim of the malarial germs *Plasmodium* as man himself. It also suffers from the disease which is characterized by gastric tumours. The same is also true of the filaria-carrying *Culex* mosquito, which suffers severely from the attack of the filarial worms. The common mosquitoes of India belong to *Culex*, *Aedes* and *Anopheles*. Besides the mosquitoes, the larvae of many other non-biting flies, midges and gnats are also aquatic.

INSECT LIFE IN STREAMS

The insect communities and the conditions of their life in streams differ fundamentally from those in ponds, and other stagnant waters. A stream differs from stagnant waters in that there is a constant flow of water. This flow acts unfavourably on animal locomotion and encourages insects to cling to some support such as submerged stones by means of hooks, suckers and other devices to save themselves from being washed away. The body is streamlined so as to offer minimum resistance to the flowing current of water. Some escape from the full force of the current by crawling under stones and pebbles. The larvae of stoneflies are common under stones in clean, cold mountain streams. They develop very slowly for one or two years; the adults emerge usually in the coldest part of the year and towards dusk, when the water level is generally low enough to permit the mature larvae to crawl out of the water on to the shore and be transformed into the winged adult. Stoneflies are common in streams fed by melting snow and ice on the Himalaya. The torrential streams in the Himalaya are also inhabited by the peculiar larvae of Blepharocerid flies. These larvae have a series of cup-like suckers on the lower side of the body, with which they secure a firm anchorage to the submerged stones over which the water rushes with velocities of one to two metres per second. Since the constantly-flowing water ensures the removal of waste products, secures the renewal of fresh supplies of oxygen and brings in new supplies of food particles, the larvae have poorly-developed gills for breathing. Their body is compact,

without sprawling legs so as to offer minimum resistance to the flowing water. If the larvae of the swift-flowing streams are kept in still water, they die within a few minutes due to lack of oxygen.

CHAPTER VIII

INSECT LIFE IN OUR DESERTS

A DESERT is essentially a region with scanty or no rainfall; the little that falls may also do so once in many years. It is a region of atmospheric aridity, with sparse, thorny vegetation. It may have low atmospheric temperatures or it may also be a hot desert, with the atmospheric temperatures sometimes rising above 50°C. Owing to low atmospheric humidity, insolation during the hours of sunshine is so intense that the ground becomes rapidly heated up. The nocturnal radiation is also equally rapid, with the result that there is nightly chill or even frost and the air temperatures fall below zero. The diurnal temperature fluctuations are thus large. Evaporation from exposed surfaces is rapid, and plant and animal bodies tend to dry up to a great extent so that organisms have to conserve their body fluids.

India is largely a land of monsoons and the distribution and abundance of plants and animals are strikingly similar to the patterns of rainfall distribution. Large areas of Rajasthan have an extremely scanty rainfall and some parts of Bikaner have no rains for several years in succession. These tracts are typical semi-deserts, extending imperceptibly into the true deserts of Sind, Arabia, and Sahara in the west.

There is a popular misconception that the desert does not support life. It is, however, the home of a numerous and diversified complex of specialized and interesting animals. As everywhere else, insects dominate animal life in deserts.

The Indian desert is peculiar in many respects, especially in its insect life. The insects take shelter from the extreme heat of the day by remaining deep underground or by concealing themselves inside stunted plants and coming out in the open during the night. The majority of the desert insects are expert diggers and burrowers. They are capable of running very fast on the loose and shifting sand. A number of them solve the problems of heat and dryness by making homes inside the hollow stems and thorns of acacias.

If you walk with a torch at night in a desert, you will be astonished at the number and variety of crickets, beetles and other insects that scurry about on the sands, meeting their friends, escaping from their enemies, hunting for food, or enjoying the cool air. The desert lives at night and sleeps and even seems dead during the day.

In the hottest part of the year, some desert insects remain in their underground shelters in a torpid state called aestivation from which they revive in winter. All are capable of withstanding high atmospheric and ground temperatures, which prove lethal to the insects of the forest and the garden. Some live happily on the burning sand at a temperature of 60°C, which will kill most of our familiar insects in a few minutes.

The problem of water scarcity has been solved by the desert insects in a variety of ways. Many live habitually at the edge of an oasis and do not stray far from the water. The majority, however, can survive with little or no moisture and can get on well with what is obtained from the apparently dry food they eat.

However dry a food may appear, it does contain a very small amount of free water and also water chemically combined with the constituents of the food. The insects are physiologically able to tap these sources.

The desert insects are well protected against desiccation of their body fluids by a hard, impervious integument that retards or even prevents the evaporation of moisture from within the body and at the same time absorbs whatever moisture there may be in the air. Even the openings of the tracheal tubes, by which they breathe, are sunk deeply under the hard integument and are protected by a filter of hairs which retards the escape of water vapour from inside. They can also be closed tightly to prevent the escape of moisture in an emergency.

Although our deserts are inhabited by hundreds of thousands of grasshoppers, crickets, bugs, beetles, ants, wasps, butterflies, moths and flies, not all of them can be described as typically desert insects. A great many of them are common in the fertile plains of the river Ganga and in the tableland of the Indian Peninsula, practically to the extreme south. They do not also show any special structures

that make them peculiarly fitted to live exclusively in an arid surrounding. Their occurrence and distribution in the semi-desert areas of Rajasthan are determined by the distribution of their food plants in these areas.

The typical desert insects are confined exclusively to the arid and semi-arid areas of Rajasthan, Sind and parts of Baluchistan. Their closest relatives occur largely in Arabia and parts of Africa, especially Sudan. Although the desert areas of India are the natural homes of many hundreds of true arid-zone insects, we confine our attention here only to the locusts, which are *par excellence* desert insects. A locust is a grasshopper, many species of which are familiar to us in the garden, grasslands, fields and forests, but it differs from an ordinary grasshopper in its behaviour.

The common grasshoppers are solitary creatures and do not show a tendency to breed gregariously or to migrate in swarms. Some desert species of grasshoppers that usually breed, feed, and move about solitarily for several years, become gregarious at periodical intervals, increase enormously in numbers in due course and migrate in great swarms over vast stretches of land and ocean, laying waste every green plant in places where they settle. Although belonging to the same species, the individuals of the solitary and gregarious populations differ so greatly in colour, size, proportions of various parts and other characteristics that they may be mistaken for different species and even genera. A locust is essentially a grasshopper that is capable of becoming gregarious and migratory in regular alternating cycles. Locusts are polymorphic grasshoppers that exist in three unstable phases, viz., the solitary phase, the gregarious phase and the transient phase, differing in structure and habits. The transient phase is a group of transitional individuals between the solitary and gregarious phases. Locusts swarm in their gregarious phase. The eggs of the gregarious phase slow down in the course of their development; this physiological slowing down is known as diapause. Migration precedes sexual maturity. The individuals of the solitary phase show no tendency for migration and their eggs develop without undergoing diapause. There is also no colour change on reaching sexual maturity.

There are many species of locusts in the world; two species are of particular interest to us in India. *Schistocerca gregaria*, the well-known desert locust, occurs throughout tropical Africa, a great part of North Africa and south-west Africa, Arabia, Iraq, Afghanistan, Baluchistan, Sind, the North-West Frontier Province of Pakistan, and north-west India. The swarms penetrate Eritrea, Spain and Portugal in the west and in the east even as far as Calcutta on rare occasions. The distributional range of this locust is separated into a permanent and temporary breeding ground into which the gregarious phase migrates.

The gregarious phase of the desert locust is composed largely of rose-coloured individuals in the young adults, which change their colour to pale yellow on attaining sexual maturity. The adults of the solitary phase are somewhat paler yellow in the sexually mature condition than the young adults. This locust has normally two generations in the year. The eggs incubate for about 15-40 days and the immature hoppers stage lasts for 40-60 days. There is a marked periodicity in the development of this locust. In the permanent breeding ground, depending upon the meteorological conditions, the breeding is limited because of natural enemies. It breeds in sandy hills with sparse vegetation and flies long distances; some locusts have been taken as far out as 1,920 km in the sea from the nearest land. Locust swarms appear roughly in cycles of eleven years, corresponding to the sunspot cycles, but there are often minor swarms of lesser duration. The conditions that determine the occurrence of swarms in eleven-year cycles are largely meteorological, but are not fully understood.

There is another important locust, viz., the Bombay locust *Cyrtacanthacris succincta*, which is confined to India. It lays eggs in June and the young hoppers hatch in July, complete their development in September and sometimes swarm over parts of the Deccan. It is very much like the desert locust in general appearance, but is more reddish in colour.

CHAPTER IX

INSECT LIFE ON THE HIMALAYA

THE INSECT LIFE of the Himalaya is extremely rich and greatly diversified. The foothills and the wooded slopes of the higher mountains are populated by a great abundance of insects of all sorts—mayflies, stoneflies, grasshoppers, crickets, dragonflies, caddisflies, bugs, cicadas, beetles, ants, wasps, bees, butterflies, moths, midges, gnats, mosquitoes, flies, etc. Some of them are indeed pioneers from the hot, dusty and humid plains of North India, which have spread within recent times, after the uplift of the Himalaya to the cooler zones of the mountain forests. We also find insects that do not occur in the plains, but which are confined exclusively to the mountains. They are the mountain autochthonous insects, viz., those which evolved on the mountains. At still higher elevations, above the upper limits of the forest, in a world of barren rock, snow, ice and glaciers, the mountain autochthonous insect life is by no means absent, though it is perhaps less varied and less abundant than within the forest. These species represent the true high-altitude insects which flourish on the Himalaya even at an elevation of 6,990 m above mean sea-level, above the permanent snowline and, therefore, at much higher altitudes than anywhere else in the world. The highest human settlements on the earth are in Tibet, at elevations of about 4,500 m, but the high-altitude insects exist at much higher elevations.

INSECT LIFE IN THE HIMALAYAN FOREST

The insect life of the Himalayan forests is composed essentially of humid-tropical forest species, which have become secondarily adapted to subtropical, montane and temperate conditions in the upper reaches of the forest. Their ancestral home was largely in countries to the east of Assam, in South China, Indo-China and partly also Malaya. The tropical forest insects which love warmth and moisture spread rapidly after the uplift of the Himalaya

PLATE XV. *Top left* *Danaus Chrysippus* visiting flowers of Vinca. *Middle left*: *Danaus Chrysippus* visiting the flowers of lantana in gardens. *Bottom left* The gregarious caterpillars of the painted lady butterfly *Vanessa*, feeding on the leaves of the Himalayan stinging-nettle, which they have webbed together with silken threads. *Right*: A *Vanessa* butterfly visiting flowers in a garden in Kashmir

PLATE XVI *Left* The lovely six spotted ladybird beetle *Chilomenes sexmaculatus* basking among flowers it feeds on aphids mainly *Top right* *Epilachna* ladybird beetle couple on a leaf of strawberry on the Himalaya Unlike other ladybird beetles, the epilachnas are vegetarians and feed on leaves of various plants *Middle right* The male staghorn beetle, with its long and toothed mandibles Though frightening in its appearance, it is perfectly harmless *Bottom* The adult blister-beetle *Mylabris pustulata* feeding on the yellow flowers of a common garden plant in its childhood it sucks the eggs of grasshoppers

PLATE XVII *Left* *Limenitis* [illegible] *Right* *Zeuxidia* [illegible] *Bottom left* *Hebomoia glaucippe* *Bottom right* *Catopsilia* [illegible]

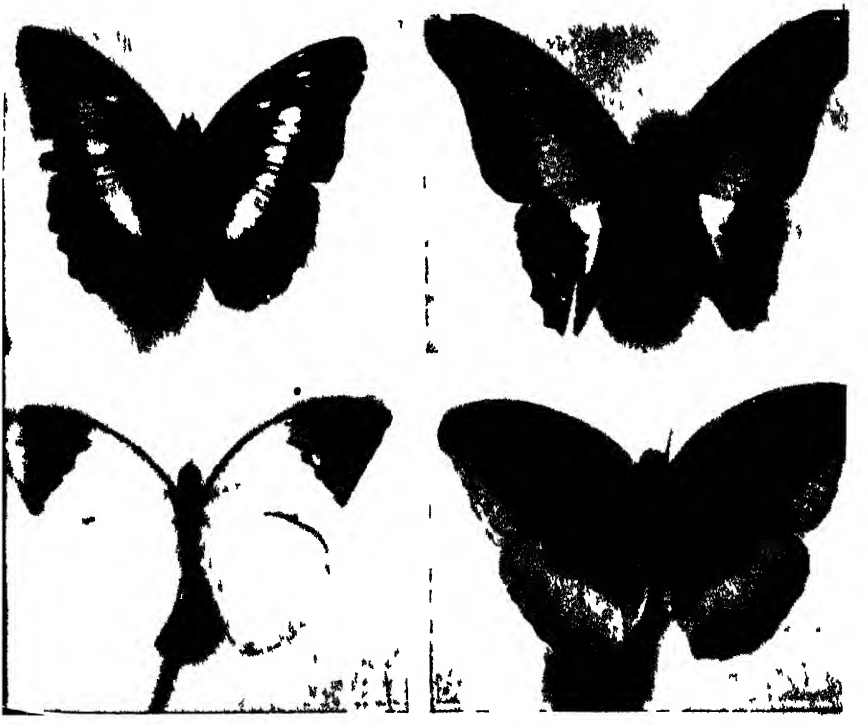

PLATE XVIII *Top* A honeybee gathering pollen grains from a flower *Top left* A Himalayan hoverfly visiting the flowers of *Primula* at an elevation of 3600 m *Bottom left* *Tenopalpus imperialis* visiting flowers *Right* A hoverfly effecting cross pollination of flowers

westwards, as far as Kashmir on the southern slopes. Some have spread to eastern Tibet on the north of the Himalaya. The beautiful butterflies *Troides* (*Ornithoptera*) of the Malayan forests are represented by *Troides helena cerberus* in the forests of the Eastern Himalaya. *Troides aeacus aeacus*, another species, extends from Formosa to the Garhwal Himalaya. The kaiser-i-hind butterfly *Teinopalpus imperialis* occurs in the Eastern Himalaya, Assam and on the mountains of North Burma. As the South-Chinese, Indo-Chinese and Malayan forest-dwellers gradually moved westwards in the Himalayan forests, they also changed fundamentally and gave rise to numerous local forms and species, differing more and more from the parental stock as they moved westwards. We thus find today a graded series of genera, species and subspecies on the Himalaya from the east to the west. The great majority of the Himalayan butterflies arose from an ancestral stock that lived formerly in Indo-China, South China, Thailand and Burma. The Indo-Chinese butterfly *Chilasa* is, for example, most abundant in the Eastern Himalaya, though it extends sparsely even up to Kashmir. *Chilasa agestor* occurs from Tonkin to Sikkim, *Chilasa agestor govindra* from Kumaon to Kashmir and *Chilasa agestor chiragshai* in West Kashmir. *Papilio bootes* extends from West China through Assam and the Eastern Himalaya to the Garhwal Himalaya. Another butterfly *Papilio rhetentor* from China and Hainan occurs on the mountains of North Burma and on the Himalaya up to Kumaon. *Papilio protentor* is found from Formosa, Hainan, China, Tonkin and Burma and extends through the Eastern Himalaya to Kashmir in the west.

The forest-covered slopes of the Himalayan ranges are the home of countless cicadas; you can hear them from all sides in the rhododendron and oak forests. There are numerous long-horned grasshoppers, praying mantids, stick-insects, leaf-insects and bugs on the barks of trees, among green foliage and among fallen leaves on the forest ground. Thousands of beetles of all types inhabit there. The firefly *Lamprophorus nepalensis* is common in Nepal and the Eastern Himalaya. Many ladybird beetles like *Coccinella* and the crock-beetle *Autocrates aeneus* with powerful mandibles and the

staghorn beetles are typical forest-dwellers of the Eastern Himalaya. *Lucanus lunifer* the king-staghorn beetle, *Odontolabis cuvera* the brightly golden coloured staghorn, *Dorcus antaeus* and *Hemisodorcus nepalensis* are some of the common beetles of the Himalaya. Many species of dung-roller and chafter beetles also live here.

Insect Life above the Forestline

The elevated regions of the Himalaya above the limits of the forest form a strange world of snow, ice and rock, characterized by low atmospheric pressure, temperature and moisture, deficient oxygen, with bacteria-free and dust-free air (though rich in fungal spores), great atmospheric aridity, constant and strong cold winds with speeds exceeding a hundred kilometres an hour, high glare and intense ultra-violet radiation. The insolation during the hours of bright sunshine is so intense that bodies exposed to the sun become rapidly heated up and their temperatures rise nearly to 50-60°C, while the temperature in the shade is hardly 7°C or even less. The radiation is equally rapid, so that even a passing cloud makes bodies cool down to temperatures often below that of the surrounding air. Owing to the low atmospheric humidity and the constant howling winds, desiccation is rapid and all bodies exposed to the air are quickly dried up. These extreme conditions are the result of the thin atmosphere—an atmosphere that is about half as dense as at sea-level. These are the conditions that preclude the life of ordinary insects, with which we are so familiar in the forest, plains and gardens and fields. These are also precisely the conditions that one is likely to find on a planet with an atmosphere about half as dense as on the earth, for example, the planet Mars. In this sense, insect life at high altitudes on the Himalaya, above the upper limits of the forest, is almost extra-terrestrial; it belongs to a wholly different world from ours. These insects were not even born in India, though they are as truly Indian as any of us are.

Living above the forestline on the Himalaya, they are highly specialized forms differing sharply from all other Indian insects, to which we have so far devoted our attention. While insects familiar to us

love warmth, sunshine and vegetation, the Himalayan insects love the cold, avoid intense light and prefer staying in their shelters under stones and snow cover or in the soil or under the cushion-like matted vegetation cover. Indeed they depend on the extreme atmospheric cold, snow and ice for their very existence. They exist on the Himalaya not in spite of the cold, snow and ice, but because of them; in their absence they cannot survive even a single minute. It is the snow and ice that provide them with all their moisture requirements. The high-altitude insects occur only at or very close to the snow edge and glacier margin and few or no insects may be found in areas free from snow. During the long and severe winter, when the atmospheric temperatures fall below –45°C, the insects remain buried and protected under the snow cover which is often 10-15 m thick; it acts as an effective blanket against subzero temperatures. They do not die, but hibernate and with the coming of spring the following year, all of them revive, become once more active and rush through their course of development within the short summer of about eight to ten weeks.

While the high-altitude insects flourish at near zero temperatures, none of them can survive even a few minutes exposure to a slight rise in temperature. Some die on exposure to the warmth of the human hand.

Their bodies are heavily pigmented and their colours generally deeper and darker than those of the species living within the Himalayan forests or in the plains of India. The dark pigmentation protects them from the injurious effects of excessive light, especially the ultra-violet, and at the same time enables them to absorb warmth when on the surface of the snow.

Though many high-altitude insects feed on lichen, moss and other plants growing at high elevations, the great majority depend for their nourishment on the pollen grains, spores, seeds, dead spiders and insects lifted from the far-off hot and dusty plains of North India by updraft air-currents in the hot weather. The air-lifted matter becomes chilled on reaching higher air layers and they are then blown by upper air currents on to the snow fields of the Himalaya. The food of the high-altitude insects is thus literally air-lifted from

the plains. The surface of the snow fields and glaciers is the regular feeding ground for these insects; it is here that they hunt other insects and spiders that come to eat the air-lifted food. As we go higher and higher on the Himalayas, there are more and more carnivorous and predatory insects; at the highest elevations the flesh eaters and hunters are the dominant types.

Insect life at high elevations is also remarkable for the pronounced predominance of wingless and flightless forms. Many of them either lack wings or have greatly reduced and useless wings, or even if they have wings, they rarely if ever fly. The very few insects which take on the wings fly only on rare and brief windless periods. In the cold world of incessant wind, flight is not only difficult, but also unncessary.

Though living in snow and ice, the high-altitude insects of the Himalaya differ fundamentally from the insects found in the Arctic and Antarctic regions. To mention only a few points of interest, the Arctic and Antarctic insects are paler than the Himalayan insects which are always heavily pigmented. In the north and in Antarctic areas the insects live *in spite of* the cold and snow, but on the Himalaya they are able to survive only *because of* them. The Arctic and Antarctic insects are, really speaking, inhabitants of the plains, but the Himalayan insects are inhabitants of a world with a thinner atmosphere than in the plains.

Most of the truly high-altitude insects are isolated on single massifs, with the result that almost every peak of the Himalaya has its own peculiar complex of insects which have risen and evolved on it. The distribution of the high-altitude insects on the Himalaya presents a curious stratification of different species at successively higher elevations. The species found at altitudes of 3,000-3,500 m disappear at altitudes of 4,000 m and are replaced by others, which in their turn disappear at elevations of 4,500 m, to be completely replaced by still others. The species found at elevations of 5,800-6,300 m do not occur at lower levels at all. As we ascend higher and higher from the forestline, there are progressively fewer and fewer species, until at extreme altitudes of 6,000 m and above we find hardly about a dozen species living permanently. At the

forestline the insect life is only about half as abundant as in the forests below. At the permanent snowline a further abrupt fall occurs and we find hardly a tenth of it at the forestline. The forestline on the Himalaya is, therefore, the threshold of the new world that is earthly and at the same time unearthly.

Unlike the Himalayan forest insects which are largely descendants of the Indo-Chinese, South Chinese and Malayan stocks, the insects above the forestline on the Himalaya are autochthonous (born on the spot) and present affinities to those of the Pamirs, Tien Shan and other mountains of Turkestan in the north in Middle Asia. Their ancestry is not at all Indian. They are really the specialized descendants of the original lowland steppes insects, which became transformed into the cold-loving high-altitude forms along with the rising of the land on which they lived to higher elevations in the course of the uplift of the Himalaya themselves. They were thus born with the Himalaya. The ground which they occupied was lifted up to the high elevations of today by the rise of Himalaya; their evolution is, therefore, an integral part of the life story of the Himalaya.

Some Typical High-altitude Insects

The principal high-altitude insects of the Himalaya are mayflies, stoneflies, some highly specialized grasshoppers mostly wingless, beetles, caddisflies, butterflies, flies and springtails. Some ants and bumblebees (but not honeybees) also live habitually at high altitudes.

The streams fed by the melting snow and ice are inhabited by the larvae of mayflies, stoneflies, caddisflies and dipterous flies. The common Himalayan mayflies are *Baetis* and the stoneflies belong to *Nemura*, *Capnia*, etc. Specialized gnats and midges spend their early immature stages in these waters; their larvae and pupae have peculiar and powerful organs of anchorage and adhesion with which they remain firmly fixed to the submerged boulders and stones in icy-cold water at temperatures of 0 5-3° C. The water in these streams flows with great force.

In glacial torrents at elevations of about 4,000 m and above in the interior valleys of the Himalaya we find the most remarkable larvae

of the mountain-midge *Deuterophlebia*. They occur on submerged stones under cascading cold water. They cling to the rock surface and crawl slowly over it with the help of pairs of false legs, ending in a circlet of sharp hooks to effect firm anchorage. They have a few pale, delicate, membranous tubes near the tail end and on their antennae, which serve as filamentous gills. The mountain-midges occur in the north-west Himalaya, Tien Shan, Altai, the mountains of Korea, Kamchatka, the Canadian Rockies and the Rockies of the United States of America. The adult flies are very delicate midges with long and slender antennae and looking very much like mayflies. These midges were first discovered in the glacial water below Haramukh Glacier in Kashmir. They do not occur in other parts of the Himalaya.

At the edge of water, melting snow and glacier margin we find many kinds of Carabid beetles belonging to *Nebria*, *Bembidion*, rover-beetles *Aleochara* and *Atheta* in addition to tenebrionid beetles. During sunny summer mornings, these beetles sally forth to the surface of the snow to hunt for prey. The surface of snow beds is generally blackened by millions of the dark-coloured snowfleas (springtails) *Proisotoma* that squirm and crawl on the snow to feed on the wind-blown fungal spores and pollen grains or other dead organic particles. A species of the rover-beetle *Atheta* occurs at an elevation of 5,600 m, which is the world record in altitude for a beetle. There are wingless grasshoppers like *Conophema* and *Gomphomastax* at elevations of 5,000 m. Peculiar looking wingless and black-coloured earwigs *Anechura* live in soil and under stones near the snow edge. There is a great abundance of hairy anthomyiid flies and hoverflies. The butterflies peculiar to the high altitudes are species of *Papilio*, *Argynnis*, *Pieris*, *Colias* and *Parnassius*. The last mentioned butterflies do not indeed occur at elevations below 3,000 m, but they ascend up to 6,300 m.

The insect life of the higher Himalaya, when compared with that of the rest of India, particularly the Peninsular area, is very young. Its youthfulness is evident in the intensity of evolution. On the Himalaya many new species of insects have risen within the lifetime

of the human race; and even at the present time the rate of species formation continues to be intense. The region is remarkable for its recent and highly specialized groups. The Peninsula is, on the other hand, notable for its relatively ancient, stable and generalized insect life, which is essentially a relict of the old Gondwana insect fauna and partly also a relict of the eastern insects that spread from the forests of Indo-China and Malaya southwards, but were cut off later from the mainstream by changes in the intervening areas of India. While the eastern insects gave rise to local forms in the Himalayan forests, they have been reduced to the level of relicts (residues) in the Peninsula of India.

CHAPTER X

INSECTS AND MAN IN INDIA

THE INDIAN INSECTS, like ourselves, belong to our motherland. They too were born here, have lived here much longer than human beings and share the same climate, food and other essential conditions of life with us. The Indian insects are indeed the original inhabitants of Bharat and man came upon the scene very much later. If the insect could talk, it would tell us incredible but true stories of the vast changes that took place in the landmass of India, of the denudation of the once proud Aravalli Mountains and of the appearance of the mighty but young upstart of the Himalaya. It would tell us how man came and how he gradually spread and colonized the whole land. It would sadly remark how untrustworthy and faithless man has proved to be. Above all, it would wonder at his stupidity, in spite of his swollen head.

From the standpoint of man, the Indian insects are broadly grouped as (i) neutral or indifferent insects, (ii) injurious, (iii) useful and (iv) beneficial insects. This grouping is of course artificial and unscientific, though a necessary fiction of convenience. It is not always possible for us to label an insect as completely injurious or completely useful. The honeybee is, for example, useful because it gives us honey and bees-wax, beneficial because it brings about the cross-pollination of flowers and injurious because it sometimes stings us. An insect, which is largely injurious at present or in some part of the country, may prove to be wholly inocuous or have no importance to man in the course of time or in some other area. We must not forget that this grouping is based on an infinitesimally small fraction of the insect life of India. There is, however, no serious harm in examining it here, as long as we do not forget that it is pure fiction.

NEUTRAL INSECTS

The greatest majority, perhaps over 99% of insect life in

India, is of wholly neutral interest to the proverbial man-in-the-street. His life and the lives of these vast hordes of inhabitants of Bharat never meet. To all intents and purposes, they just do not affect each other. It is totally a matter of complete indifference whether these insects live or die. They are only of academic interest to the few to whom we condescendingly refer as Nature lovers. Even the specialists in the agricultural, forest and veterinary departments do not meet them and do not know much about them. These insects lead their lonely lives, quietly contributing to the general balance in Nature and pass out of existence unsung, and without leaving behind a trace. Where are they to be found ? Everywhere, in soil, in the grass, in the forest, in water. As mentioned at the very beginning of this book, we would not have had our vegetation, landscape and many other things but for them.

Injurious Insects

The injurious insects interfere with some desired object of man, and prevent him from getting it or enjoying what he has taken possession of. They destroy his crops, vegetables and fruits, spoil his stores of harvested grains, raw products and manufactured goods, and make them unfit for his use; damage furniture, clothing, valuable records and works of art; cause annoyance, pain and bodily injury or transmit the pathogens of diseases. They bite his domestic animals or transmit fatal diseases to them. Often they are enemies of other insects which are useful or friendly to man and friends of man's enemies; those who are not with us are usually deemed to be against us.

The damage caused by insects to agriculture, industry, animal husbandry and public health is not, however, always considerable. When the damage is of such magnitude or nature as to cause appreciable economic loss to the community, the insect is called a "pest". Fortunately, only a very few species of our insects are pests in the strict sense of the term. Unlike those of some other countries, it is these infinitesimally small minority of Indian insects that worry our agricultural entomologists, though the conservative Indian cultivator, in his traditional wisdom, remains unperturbed.

We cannot give here a list of the very "few" pests in India, because even such a list would be very long and out of place. We may, however, mention some of them by way of illustration.

Locusts naturally head any list of injurious insects; it is difficult to say how many nations they have totally ruined. Next to them come the termites, which are among the most destructive insects for man. They destroy tea, sugarcane and other standing crops, orchard trees, timber and wood, wooden furniture and household articles. Then there are the paddy grasshoppers like *Hieroglyphus banian* and *Oxya velox*, the paddy bug *Leptocorixa variicornis*, the rice *Hispa armigera*, the larvae of various moths which bore into the sugarcane stem. The cotton crop is extensively damaged by the bollworm larvae of the moths *Earias* and *Platyedra*. The potato is spoilt in the field and godown by the larvae of the potato-moth. The fruitflies *Dacus* breed in fruits of cucurbits, orange, mango, etc., and completely ruin them. The larva of the codling moth damages apples. The rice-weevil *Calandra oryzae* and the granary weevil *Calandra granaria* spoil rice and wheat in storage. *Tenebrio*, *Silvanus*, *Corcyra*, *Sitotroga*, etc., and other insect larvae breeding in flour and other cereal products in store and render them utterly unfit for human consumption.

In addition to the numerous insects which attack crops, fruits, vegetables and stored products, there are those which transmit various diseases in man. Some of the insect-borne diseases of man are the malarial and yellow fevers, sleeping sickness, filariasis, bubonic plague, typhus, typhoid, cholera, dysentery, diarrhoea, myasis, oriental sore, sandfly fever and other tropical diseases. The important transmitters of human diseases are the mosquitoes, sandflies (*Phlebotomus*), houseflies, fleshflies, eyeflies, head and body lice, rat fleas, etc. A number of insects attack cattle, horses, dogs, poultry and other domesticated animals and give rise to fatal diseases in them and are also injurious to man. Diseases of vegetables, crops, fruits, etc., are transmitted by aphids, whiteflies, etc., which must also be considered as harmful to man.

USEFUL INSECTS

The useful insects provide man with food, clothing, medicines, wax, lac, dyes and numerous other valuable products. Many insects and their larvae are eaten with relish in many parts of India and the world. Locusts, grasshoppers, beetle grubs and other insects are fried in fat, suitably seasoned and eaten in many parts of Africa, Egypt, Sudan, Arabia and the United States of America. Cooked grasshoppers dipped in chocolate are served in many fashionable restaurants in the United States. Among many forest tribes in our own country, the white-ants and beetle grubs are fried in ghee, seasoned with masalas and boiled with rice to make a hearty feast.

Honey, a wholesome food for man, from time immemorial, is produced by the honeybees. Bees-wax is also produced by the honeybees and is extensively used in industry and medicine. Silk produced by the caterpillars of the moths *Bombyx*, *Attacus* and other silkmoths has been most highly valued in India from the Vedic times. The Vedas describe, for example, God as creating the universe out of Himself, just as the silkworm produces the silk from within itself. The *Ramayana* mentions the use of silk. Lord Vishnu is described as robed in yellow silk and the Goddess Saraswati as wearing white silk. Lac, the resin produced by the lac-insect *Tachardia*, has been used in India since ancient times and even the modern synthetic plastics have not been able to do away with the monopoly in lac held by India. Anyone who has read the *Mahabharata* must have marvelled at the idea of building a palace of lac that could conveniently be set fire to with a view to destroying the enemy. The lac dye was also used in our country in dyeing cloth until recently. The carmine dye, extensively used in colouring sweets and in cosmetics, is extracted from a coccid bug (the cochneal insect) that lives on cactus plants. The manna, mentioned in the *Bible*, is the dried and solidified honeydew secreted by the bug *Trabutina*, living on the tamarisk trees. The galls, produced by cynipid wasps as tumours on oak trees, have been employed since long in the manufacture of ink, dyes and in tanning leather. Cantharidine for medicine and for the manufacture of hair oils is

obtained from blister-beetles like *Lytta*, *Meloe* and *Mylabris*. The elytra of the beautiful metallic and iridescent jewel-beetles and the wings of the *Morpho*-butterfly are used in inlay and gem-work in the manufacture of jewels. The maggots of certain fleshflies produce an antiseptic and bactericidal agent, known as allantoin, which prevents putrefaction of open wounds and sores of man and hastens their healing. The aquatic larvae of mayflies and even of the mosquitoes are useful as the food of many valued food-fishes. Different kinds of flies serve as excellent baits in angling. The bananafly *Drosophila*, which completes a generation within a few days, has been extensively used in the United States and other places in researches in genetics. Its use has facilitated the discovery of many laws of inheritance of hybrid characters.

Beneficial Insects

The beneficial insects promote the objectives of man in some way or other. Though they are not used by man as food or clothing and medicine, their activities benefit him in a number of ways.

Many insects are enemies of other insects which are harmful to agriculture, industry and public health—they are enemies of our enemies and must, therefore, be considered as being on our side. They often destroy noxious weeds in garden, field and orchard and thus help us in increasing the production of flowers, crops, fruits and vegetables. The beneficial insects are, in effect, our collaborators and comrades.

The most important, though usually unrecognized, class of beneficial insects helps man in raising his crops, seeds, vegetables, nuts and fruits by bringing about the cross-pollination of flowers. With the exception perhaps of the small number of wind-pollinated flowers, all plants depend solely on different insects for effecting the cross-pollination of their flowers. The plants have in reality evolved flowers expressly for the purpose of attracting specific insects, bribing them with sweet food and then making them carry pollen grains from one flower to another and depositing part of the load of pollen grains on the stigma before departing. These plants are known as entomogamous; their flowers are so constructed that only

a specific insect and no others can enter them. The preferred species of insects is guided by vivid colours, hairs, markings and other methods (honey-guides) directly to the nectary and stamens or pistil, so that it does not have to waste time and energy searching for the nectary. The flower-visiting insects are also, on their part, so highly specialized in their anatomy and in their habits that they can visit and feed only in a specific flower and in no others. They are made precisely for each other. They have also the organs for puncturing the nectaries and sucking the sweet nectar, gathering the pollen grains as food and for transporting them during flight. The flowers may indeed be grouped on the basis of the insects that visit them for cross-pollination. We thus have the Hymenoptera flowers, with concealed nectaries and often with a very complicated flower mechanism, which can only be operated by the intelligent Hymenoptera like the honeybees, bumblebees and carpenter bees. To this category belong, for example, the flowers of *Scrophularia*, *Iris*, *Primula*, *Aconitum*, Labiatae, orchids, Papilionaceae, etc. The Lepidoptera flowers have long tubes, at the bottom of which the nectaries are cleverly hidden, but the pollen-bearing stamens are prominently exposed, with or without places for the butterflies and moths to sit while sipping the nectar. Lilies, *Phlox*, *Dianthus*, etc., are some of the typical butterfly-flowers and *Lonicera*, *Saponaria*, etc., are some of the mothflowers. The Diptera flowers are generally white or blue in colour and have the nectaries exposed and readily reached as in *Veronica* or partially hidden as in *Arum*, *Aristolochia*, Asclepiadaceae, etc. Ficus is a special case, in which the female of the chalcidoid wasp *Blastophaga* effects the cross-pollination.

The cross-pollination of most orchard trees, nearly all our vegetables, all leguminous crops, oilseeds, cotton, tobacco, coffee, many fodder crops and dozens of other valuable plants yielding drugs and other products is brought about entirely by the agency of different insects. It is most advantageous to keep bee-hives in orchards to secure an abundant fruit crop. If insects declare a "work-to-the-rule" and refuse to pollinate the flowers, then man could never grow pulses, oilseeds, cotton, mango, orange, apple, pear and fig, to name only a few. Acute malnutrition will eliminate

more than half the human race and solve the so-called population-explosion problem.

A second important class of beneficial insects of India includes the insects which feed on various weeds and helps keep them in check. Every weed in our field or orchard or backyard is attacked by one or more insects; this prevents the weeds from overwhelming the land. The most classical example of a weed-destroying insect in India is the prickly-pear cactus mealybug, *Dactylopius tomentosus*. Over forty years ago the common prickly-pear *Opuntia* formed impenetrable barricades in fields and all but ousted cultivation in many parts of South India. Then came the mealybug; it bred on the prickly-pear in such enormous numbers that the weed was almost totally eradicated and is no more the menace that it was before.

A third class of beneficial species are the predators and parasites of insects which are injurious to man. Being enemies of our enemies, they are our friends, collaborators and "fifth-column-guerilla-fighters" in man's war against the insect pests of crops. It is a great misfortune for insects and a good fortune for man that the most implacable enemies of insects are insects themselves. We can never hope to repay the heavy debt due to the beneficial insects for the inestimable good they are doing to mankind everywhere. The common predators like praying mantids, dragonflies, cicindelids, carabids, ladybird beetles, hornets, wasps, ants, robberflies and others systematically hunt for and destroy countless thousands of grasshoppers, crickets, flies, mosquitoes, caterpillars, aphids and other injurious insects every hour of the day. The tireless predators know precisely where to look for and how to overpower and kill the agricultural "pests", a knowledge which man still cannot claim to possess in full. If he is to succeed in controlling any harmful insect, he will have to depend on the superior knowledge and power of his insect friends, and leave them free to do the job for him.

Not only the predatory insects, but also the entomophagous parasitic insects eliminate almost ninety per cent of the population of injurious insects. They manage to do this unobtrusively and with maximum efficiency by attacking their eggs, larvae, pupae, etc. They seek out the most vulnerable stages of the harmful insects far

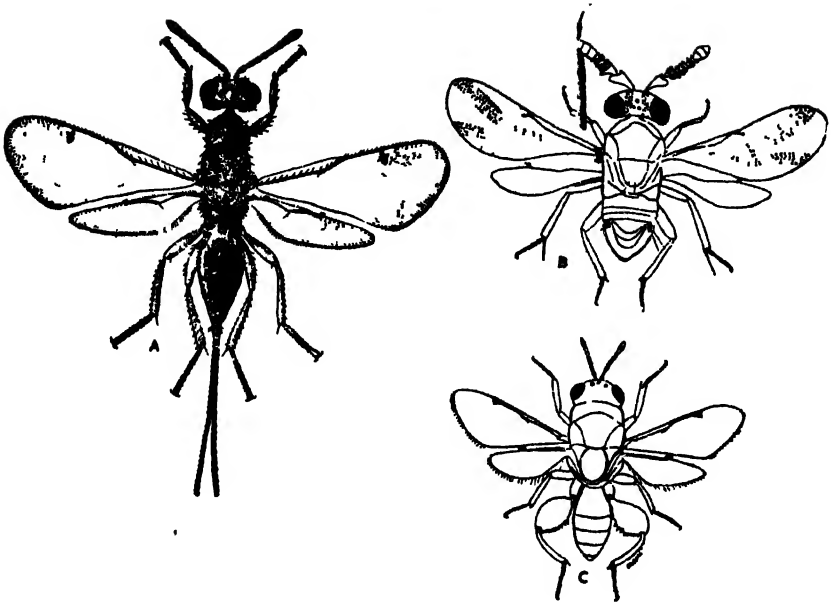

FIG. 13—Some common entomophagous parasites of insects; magnified.

better than any cultivator can hope to do. The major parasitic insects of India belong to the Hymenoptera and Diptera. The Hymenopterous parasites are mainly the Ichneumonids, Braconids, Evaniids, Chalcidoids, Proctotrypids and Bethylids. Among the Diptera the most important entomophagous parasites in our country are Tachinids.

No less than five thousand entomophagous parasitic insects are so far known in India, there being many more still to be discovered. Nearly every one of them is beneficial to man. We cannot hope to give here even a sketchy account of the habits and life-histories of these parasites. We refer to some of them by way of example. The eggs of the paddy-grasshoppers are parasitized by the Proctotrypid *Scelio* and the adult grasshoppers are themselves parasitized by Tachinids. Very often over 70% of the grasshopper eggs in a

locality may be found parasitized. The caterpillars which feed on leaves of our crop plants are heavily parasitized by Braconids like *Apanteles* and Chalcidoids like *Brachymeria*. The chalcidoid *Trichogramma* is a tiny fly, about one to two millimetres long. It is, however, rated as one of the most beneficial of the Hymenopterous parasites; it attacks the eggs of a great variety of Lepidoptera, nearly all of which are injurious to agriculture, vegetables and forest trees.

Insects in the Pay of Man

Man was not slow in realizing the importance of the role played by parasites and predators in checking the ravages of insect pests. Two brilliant American entomologists, Howard and Riley, hit upon the idea of rearing the predators and parasites artificially in the laboratory in sufficiently large numbers and releasing them in the field to attack the pests. This method of dealing with insect pests is known as biological control. A number of pests have been controlled with the help of predators and parasites with spectacular success in the United States of America and in India. Man has pressed into his paid service the beneficial insects in waging his war against insect enemies.

The first and perhaps the most successful utilization of a predator in the control of an insect pest in India was the introduction of the ladybird beetle *Rodolia cardinalis* in the control of the fluted scale insect *Pericerya purchasi* in South India. This insect was originally a native of Australia, where it fed on acacia and was not a serious pest of fruit trees or of crops. Early in the beginning of the present century it was accidentally introduced into South India, along with some of the ornamental avenue acacias brought from Australia. In the course of a few years, it spread unobtrusively but rapidly and started attacking a great variety of orchard trees in the Nilgiri Hills and threatening the fruit industry. Following the success of its utilization in America, the ladybird beetle was introduced from America into South India, mass cultured and liberated in the field. The ladybird beetle, which is a predator on the scale insect, soon brought it down to a harmless level. The use of the mealybug

Dactylopius tomentosus in eradicating the prickly-pear cactus in South India, to which we have already referred, is another instance of biological control. The use of *Trichogramma* egg parasite for controlling the moth borer caterpillars which attack the stems of sugarcane and defoliate forest trees like teak has also proved very successful. In employing the trichogramma egg parasites, the parasites are mass-produced in the eggs of *Cocryra cephalonica*, the larvae of which breed in crushed millet grains in the laboratory. The eggs of the moths are glued to pieces of cardboard of convenient size, exposed to the female trichogramma for egg-laying, then taken out and attached to the sugarcane or other plants to the field. The adult parasites that emerge from these eggs, seek out the eggs of the sugarcane borer moths, laid on sugarcane leaf, and lay their eggs inside them. The pest is thus killed even before it has had time to attack the crop. The effect of the release of parasites in the field lasts for some time before it becomes necessary again to make a second release. The techniques of mass-rearing of the trichogramma parasites in the laboratory, keeping them in cold storage till required, transporting them by post, releasing them in the field and other work involved in biological control have been greatly refined in recent years. The fundamental condition in all such work is the recognition of the fact that predators and parasites of insects are on the whole beneficial to man. The special advantage in their use is that they are selective in killing and not indiscriminate like our insecticidal sprays and dusts.

The Balance-sheet of Insect-man Partnership in India

The association of insects with man, or more correctly, of man with insects, is very ancient in India. When man arrived, the insect inhabitants accepted him and readily assimilated him. The Indian cultivator and the Indian insects adjusted themselves to each other and established a more or less stable and dynamic equilibrium in Nature, into which all other animals fitted themselves. Insect and man lived in peace, respecting each other's needs and powers of good and evil and a code of intimate partnership was firmly established and followed. This partnership had the result that the overall

insect damage to crops and the interference of insects in the affairs of human health never departed widely from a low annual average, year after year and century after century. The cultivator rigidly followed traditionally tested crops and practices and the insects always saw to it that he had his bumper crop harvest. Leaving aside the calamities due to the vagaries of the Indian monsoon rains, droughts and floods, famines in India were never brought about by insect damage to crops. If man starved occasionally in India the fault was not of the insects. The cultivator was only vaguely conscious of insects in the field, but he never felt them, much in the same way as we never feel the presence of our stomach, until one day we have a stomach-ache, the result of over-indulgence. Insects abounded in India then even as now, but "pests" there were none or were rarities. which the farmer was sure would be eliminated soon by natural agencies. He trusted these agencies and let them carry on their appropriate duties.

This partnership of insect and man in India presents a wholly different picture from what prevails in the United States of America, where agriculture is much more efficient and modernized than ours. One may perhaps wonder if the Indian insects, like the true Indians that they are, should be following the path of ahimsa and dharma, while the American insects do not have the time to bother themselves about such virtuous thoughts. The fact is that American agriculture is a thing of yesterday, when compared to Indian agriculture. India has been cultivated for at least seven thousand years, if not more. The settlers in America took with them to the new country many of the Old World crops. The crops introduced there soon attracted the attention of the native American insects which spread and became "pests" rapidly. When the settlers took the Old World plants, they also carried the insects which fed on these plants; in Old World homes, they were not pests, because they were kept down to their level by their natural enemies, the predators and parasites. When the Old World plants and their insects went to America, the predators and parasites were left behind and denied entry into America. Therefore, the Old World insects not only spread rapidly on the old crops in the new country, but also readily developed a taste for the

new crops like corn and became pests on these as well. There was not enough time to bring about a natural equilibrium between the cultivator and the insects in America, as it had happened in India. Worse still, even before such an equilibrium could occur, the Americans in their characteristic haste speedily resorted to newer methods of raising more crops and fruits on larger and larger holdings, so that a partnership of mutual benefit between insect and man could not come about.

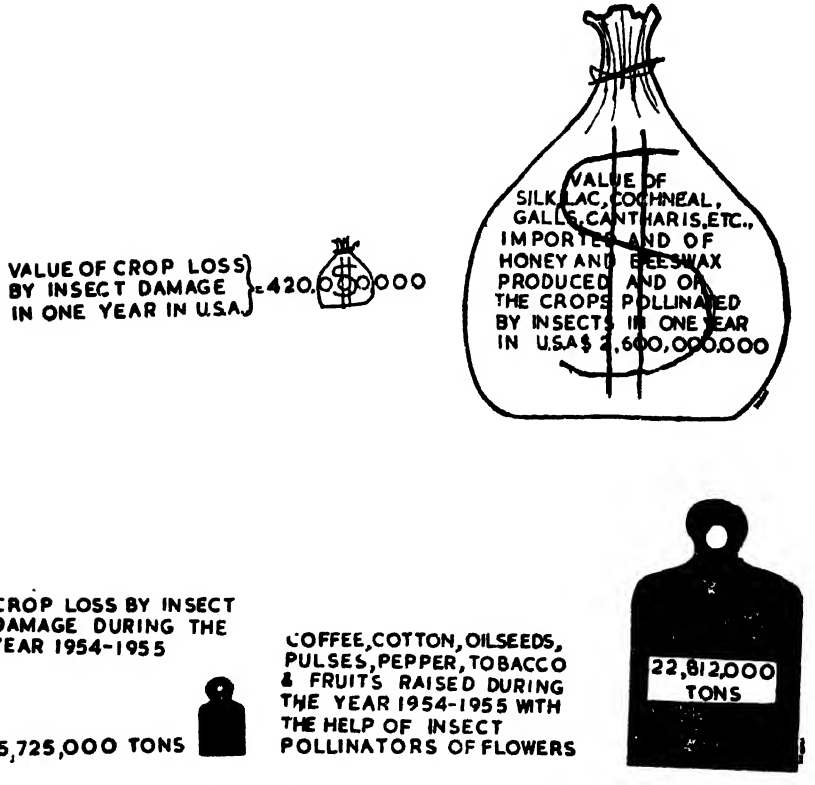

FIG. 14.—The balance-sheet in the insect-man partnership; man is heavily in debt to the insects. The good that insects do to man far outweighs the harm done by them.

It is this basic difference between India and other "developed' countries that is consistently being overlooked by our specialists, who in their haste to "grow-more-food" decry the traditional practices of the Indian cultivator. If any insect has recently proved to be a "pest" of agriculture in India, it is the result of our attempts to compel the hesitating cultivator to adopt "modern improvements". These pests are thus creations of modern man's folly. The primary responsibility in upsetting the partnership equilibrium is that of man.

When we use some of the powerful modern insecticides like DDT, BHC, etc., in control operations in agriculture, we unfortunately kill not only the so-called "pests", but also the predators and parasites, which are our friends. It is these beneficial insects which have laboured to maintain the equilibrium undisturbed. How then can you blame the insects if as a result of the death of the beneficial species, the equilibrium is upset ? The "pests" in course of time build up effective resistance to the insecticides and unchecked by their natural enemies, multiply even more rapidly than before. In our alarm, we renew our efforts, and to meet the situation created entirely by ourselves, resort to stronger and quicker acting insecticides, which eliminate even the few beneficial species that may have by chance survived the first treatment. It is again only a question of time before the injurious insects develop resistance to the newer chemicals and the vicious circle is complete. Our twofold crime consists in unilaterally abrogating the pact with insects and subjecting even our insect friends to the methods of modern scientific agriculture.

There is another widespread popular misconception in India. We seem to think that if there were no insects, we could grow more food to feed all human mouths. This is really a crude attempt to cover up our idleness. The truth is that the overall damage done by insects to man in India is very much less than, for example, in the United States of America; the good the insects do to man, both in India and in America, far outweighs the total harm done by all insects combined. The credit in the balance-sheet of insect-man partnership is heavily in favour of the insect. When all is said

and done, man is a debtor. The estimated total economic loss by insect damage to crops, fruits, livestock, raw materials, manufactured goods, human health, etc., is only a small fraction of the grains, fruits and vegetables and fodder raised by the insect pollinators for the use of man. Add to this the cost of removal of filth, carrion, the improvement of soil, destruction of weeds by insects, and man's debt assumes incredible proportions. How can man ever repay it to the insects ? Frankly, he cannot afford to do so even if he is keen on paying it; at best he can only show his appreciation by befriending the insects.

In India it is a most stimulating and rewarding experience to befriend insects; it is also an inexpensive hobby and an abiding scientific achievement, within the reach of anyone who wants to know our fellow citizens. We know practically nothing of the habits, life-histories, needs, urges and performances of even our most common insects. When we approach them in a spirit of understanding, we will find that they have solved the problems of life—the same problems as we face—in their own way. Sometimes our way appears to be superior and at other times theirs. Really speaking, both are equally successful and lead to the same result. If we understand the insects fully, we will marvel at the fact that they and man are inseparable, integral and interdependent cogs in the same wheel of life. Whether in an insect or in a man life is the same; *Eko vasi sarvabhutarantarathma*—it is the One that pervades all created things.

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